DYNAMICS OF GAS - SOLID SEMI-FLUIDIZATION

THESIS SUBMITTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE
OF
MASTER OF TECHNOLOGY
IN
CHEMICAL ENGINEERING
(Petroleum Refinery Engineering And Petro-chemicals)

BY
G. K. ROY

DEPARTMENT OF CHEMICAL ENGINEERING
INDIAN INSTITUTE OF TECHNOLOGY
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C E R T I F I C A T E

This is to certify that the thesis entitled "Dynamics of Gas-Solid Semi-fluidization" which is being submitted by Sri G. K. Roy, in partial fulfilment for the requirements of the award of the degree of Master of Technology in Chemical Engineering (Petroleum Refinery Engineering and Petro-chemicals) is a bonafide record of investigations carried out by him under my supervision and guidance.

Dated the 25th June,1971.

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Dated, June 25th, 1971.

GKRoy.

(G. K. Roy)

CONTENTS

SYNOPSIS

"DYNAMICS OF GAS-SOLID SEMI-FLUIDIZATION"

The merits of semi-fluidization as compared to the packed bed and fluidized bed operations have been emphasized. Application of semi-fluidization technique in the fields of heat transfer, mass transfer and reaction kinetics has been suggested.

The thesis has been presented in four chapters :

Chapter I :

A detailed literature survey of the previous investigations in semi-fluidization relating to heat, mass and momentum transfer studies has been made. Future scope and objectives of the present work have been underlined.

Chapter II :

A detailed description of the experimental set-up, the method of calibration, the experimental procedure, special precautions taken and the method of determination of surface area of particles has been given. Air at about 22^0 C has been used as the fluidizing medium.

The semi-fluidizer consists of a perspex tube of 4.5 cm. i.d. and about 57 cm. long, fitted with an inclined feeder and a movable top restraint.

Altogether 141 sets of runs have been taken. Two spherical materials viz. mustard seed and sago of size 14/20 BSS and four non-spherical materials like, table salt, sand, magnesite and ammonium sulphate of size 30/40 BSS, have been studied. In addition, four size ranges,20/30, 30/40, 40/52 and 52/60 BSS have been studied for table salt only. The lowest and highest densities of solids used are 1.12 and 2.80 gm./cm^3 respectively.

<u>Chapter III</u>.

Dynamics of semi-fluidization has been investigated and a few correlations have been developed.

A. Maximum semi-fluidization velocity -

From the experimental data, the following correlation has been developed for the prediction of the maximum semi-fluidization velocity from a knowledge of the physical characteristics of the fluid and the solid -

$$G_{msf} = 9.1 \times 10^{2} \, (d_p)^{1.028} \left[\rho_s (\rho_s - \rho_f) \right]^{0.676} \qquad \ldots \quad \ldots (1)$$

Based on the above equation, a nomograph is suggested for rapid estimation of the maximum semi-fluidization velocity.

B. Minimum semi-fluidization velocity -

The ratio of the minimum to the maximum semi-fluidization velocity has been correlated to the system variables as under -

$$\frac{G_{osf}}{G_{msf}} = 48.0 \left[(D_c/d_p)^{0.38} (\rho_s / \rho_f)^{-1.05} (R)^{0.64} \right] \qquad \ldots \quad \ldots (2)$$

A nomograph based on the above equation has also been tried for the rapid prediction of minimum semi-fluidization velocity.

C. Relationship between minimum semi-fluidization and minimum fluidization velocity -

A relationship between the minimum semi-fluidization and minimum fluidization velocity has been attempted in terms of the system parameters as -

For spherical particles,

$$\frac{G_{osf}}{G_{mf}} = 3.4 \times 10^{3} \, (D_c/d_p)^{1.11} \, (\rho_s/\rho_f)^{-1.78} \, (R)^{0.89} \quad \ldots \ldots (3)$$

For non-spherical particles,

$$\frac{G_{osf}}{G_{mf}} = 2.66 \times 10^{2} (D_c/d_p)^{0.62} \, (\rho_s/\rho_f)^{1.0} (R)^{0.50} \quad \ldots \ldots (4)$$

Chapter IV.

Pressure drops across the semi-fluidized bed have been calculated by different theoretical equations and have been compared with the experimental values. The following equations have been suggested in terms of the system variables for the prediction of the exact value of the pressure drop from the calculated values:

For spherical particles,

$$\frac{(\Delta P_t)_{actual}}{(\Delta P_t)_{calculated}} = 7.3 \times 10^{-3} \left[(D_c/d_p)^{-0.53} \, (\rho_s/\rho_f)^{1.18} \, (h_s/D_c)^{-2.05} \, (R)^{1.56} (h_{pa}/h_s)^{0.64} \right] \ldots (5)$$

For non-spherical particles,

$$\frac{(\Delta P_t)_{actual}}{(\Delta P_t)_{calculated}} = 1.95 \times 10^{-1} \left[(D_c/d_p)^{-0.24} \, (\rho_s/\rho_f)^{0.55} \, (h_s/D_c)^{-0.94} \, (R)^{0.72} \, (h_{pa}/h_s)^{0.29} \right] \ldots (6)$$

Nomenclature.

References.

Appendix.

The development of the equation for the measurement of particle surface area has been given. A typical experimental run along with the sample calculations has also been given.

INTRODUCTION

INTRODUCTION

In many chemical plants we very often come across situations where a solid phase has to be kept in contact with a fluid phase, viz. drying, adsorption, solid catalysed reactions, heat transfer etc. In all these cases, the technique of fluid-solid contact is very essential and developments to increase the efficiency of contact are always welcome.

Of the various two-phase contact operations, mention may be made about packed bed, fluidized bed (batch as well as continuous) and the semifluidized bed. In case of batch fluidization, if the free expansion of the bed is restricted by the introduction of a porous disc or sieve, the particles will be carried and adhere to the sieve resulting into the formation of a packed bed at the top. In other words, by the introduction of a restraint some of the particles are distributed to bottom section(which is in the fluidized state) and the rest to the top (which is in the form of a packed bed). This phenomena of solid-fluid contacting, comprising the features of both fixed and fluidized beds is termed in literature as "Semifluidized beds" .

The semifluidization technique overcomes the disadvantages of fluidized beds viz. back-mixing of solids, attrition of particles and problems involving erosion of surfaces. At the same time certain inherent drawbacks of the packed bed, viz. non-uniformity in bed temperature, channel flow and segregation of solids are taken care of if the bed is fluidized, at least partially.

Application of semi-fluidization technique in the field of reaction kinetics has already been initiated. This method is advantantageous for fast exothermic reactions such as vapour phase oxidation and chlorination of hydrocarbons etc. A semifluidized bed reactor can be operated with steep temperature gradients in one section and a uniform temperature in other section, with no elutriation of solids and a low pressure drop. Use of this technique in studies relating to mass transfer have shown that the magnitudes of mass transfer coefficients can be controlled approximately linearly, and can be maintained within the limits of a completely fixed bed and fully fluidized bed by means of bed expansion alone.

Thus semi-fluidization can be regarded as a compromise between the fixed and fluidized bed conditions wherein the particles can be distributed into two sections as desired by chosing the parameters like restraint position, fluid velocity etc. A glance into the literature reveals scanty, informations in this field(especially in gas-solid semi-fluidization). Several aspects of this operation like the direct prediction of minimum and maximum semi-fluidization velocities, the pressure drop across the bed and developments leading to new processes based on this technique are yet to be explored. The system parameters governing the operation are to be synthesised to result into some working correlations. With this end in view, the present work has been taken up and restricted to gas-solid semi-fluidization.

CHAPTER-I

LITERATURE SURVEY

LITERATURE SURVEY

Semi-fluidization is a new and unique type of fluid-solid contact operation, which has been reported only in the last decade. Like the packed bed and fluidized bed operations, this is also a two-phase phenomena. A semi-fluidized bed is a compromise between the packed and fluidized bed conditions and has been achieved in a conventional fluidizer by incorporating certain modifications in the column design.

In case of batch fluidization, if the free expansion of the bed is restricted by the introduction of a porous disc or sieve, then the particles will be carried upwards and a portion of it will adhere to the sieve, resulting in the formation of a packed bed at the top. The remaining materials of the system will form a fluidized bed below the layer of packed bed. Such a fluidized bed having restricted expansion comprises the features of both fixed and fluidized beds and is termed in literature as 'Semifluidized beds'.

Fluidized bed technique as compared to fixed bed has specific advantages. These are :

(i) the fluidized bed ensures uniform contact of the fluid with all the particle surfaces,

(ii) it prevents segregation of solids because of the turbulence,

(iii) the temperature variation is minimised i.e. local heat spots are avoided.

As against these the fluidized bed suffers from certain serious defects:

(i) loss of driving potential for transport processes within the bed because of the intense back-mixing,

(ii) attrition and elutriation of solid particles which necessitate costly dust recovery systems,

(iii) non-availability of necessary free space above the bed, and

(iv) erosion of the containing vessel.

As a result, wholesale substitution of fixed bed processes by fluidized ones has not been feasible because of the above drawbacks. An answer to this problem is to use a semifluidized bed, which has been thought of in recent years. This can be regarded as a compromise between the fixed and the fluidized bed conditions wherein, the particles can be distributed into two sections as desired by choosing suitable parameters like restraint position, fluid velocity etc. Further, semi-fluidization offers greater flexibility of operation. By adjusting the position of the movable top restraint, the overall bed porosity may be varied.

Semi-fluidization technique will have immense applications in various fields of chemical engineering in the near future. Its application in the field of reaction kinetics has already been , initiated . It is preferred in cases where a combination of back-mix and tubular reactor(MT reactor) is used, especially, for fast exothermic reactions like the vapor phase oxidation and chlorination of hydrocarbons. In exothermal reactions, an optimum performance may be obtained with an MT reactor, and depending on the prevailing conditions, a higher conversion would be obtained or a smaller residence time[3]. Moreover, a semi-fluidized bed reactor can be operated with steep temperature gradients in one section and an uniform temperature in the other section, with practically no elutriation of solids and low pressure drop. Use of this technique of semi-fluidization in mass transfer studies has shown that the magnitudes of mass transfer coefficients can be controlled approximately linearly, and can be maintained within the limits of a completely fixed bed and fully fluidized bed by bed expansion alone.[4]

A review of the existing literature on semi-fluidization has been made by Roy and Sarma.[16,17] In general, studies relating to various aspects of semi-fluidization can be broadly classified as under :

(i) Momentum transfer studies

(ii) Studies relating to mass transfer, heat transfer and reaction kinetics.

MOMENTUM TRANSFER STUDIES:

Investigations in the field of momentum transfer are relatively more and various aspects of the semi-fluidization phenomena have been reported. The studies related to momentum transfer can further be subdivided into

(i) studies oriented towards the prediction of the onset-and the maximum semi-fluidization velocities,

(ii) studies oriented towards the prediction of packed bed formation, and

(iii) studies relating to the prediction of total pressure drop in a semifluidized bed.

I. MINIMUM AND MAXIMUM SEMI-FLUIDIZATION VELOCITIES:

(a) Minimum Semi-fluidization Velocity:

Fan, Wen and Wang [4] were the pioneer investigators in the field of semi-fluidization. They had initiated their work with studies on mass transfer. Later on they studied the mechanical and dynamical characteristics of semi-fluidized beds of single size particles both in liquid-solid[5] and gas-solid systems. Although no correlation was suggested for the direct prediction of the minimum semi-fluidization velocity, Fan et.al. commented that the velocity is dependent on the fluid and the particle characteristics, and also on the relative quantity of solid particles to the column (h_s/h, also called 'bed expansion ratio in semi-fluidization' by other authors). When $h_s/h = 1$, the minimum semi-fluidization velocity approaches the value of minimum fluidization velocity (G_{mf}), and when $h_s/h = 0$, i.e. the top restraint is kept at a much higher level as compared to the initial static bed, the value approaches the terminal velocity or the maximum semi-fluidization velocity. Thus the minimum semi-fluidization velocity has a value between the onset of fluidization and the maximum semi-fluidization velocity depending on the value of h_s/h, which is again between 1 and zero. Both Fan et.el.[6] and Babu Rao et.el. remarked that the velocity can be obtained directly from the total pressure drop vs mass velocity plot.

Poddar and Dutt[10] suggested the following equation for the prediction of minimum semi-fluidization velocity in a liquid-solid system:

$$18\ Re_{osf} + 2.7\ Re_{osf}^{1.687} = 0.966\ \phi_s^{0.88}\ Ga\ \left[1 - \frac{h_s}{h}(1 - \epsilon_{pa})\right]^{-4.7} \qquad \text{.. .. (1.1)}$$

$$\text{where,} \quad Re_{osf} = \frac{d_p\ G_{osf}}{\mu} \qquad \text{.. .. (1.2)}$$

The value of G_{osf} has to be calculated by a trial-and-error procedure. The basis of the above equation was stated to be the expanded bed voidage function as proposed by Wen and Yu (25)

For liquid-solid system, Roy and Sarma[18] have suggested an equation for the direct prediction of the minimum semi-fluidization velocity,

$$\frac{G_{osf}}{G_{msf}} = 0.105\ (R) + \frac{\log\ (Ar.) + 2.465}{52} \qquad \text{.. .. (1.3)}$$

Based on the above equation, a nomograph has been suggested by the authors[22]

(b) Maximum semi-fluidization velocity :

It is the fluid velocity corresponding to which the entire solid particles are transfered to the top and give rise to a packed bed formation almost equal to the initial static bed. This velocity also corresponds to the terminal free fall velocity of the particles. There are three methods of estimating the maximum semi-fluidization velocity:

(i) linear extrapolation of expanded bed voidage (ϵ_f) vs. fluid velocity curve to the value of $\epsilon_f = 1.0$,

(ii) extrapolation of h_{pa}/h_s vs. fluid velocity curve to the value of $h_{pa}/h_s = 1.0$, and

(iii) by calculation of terminal free fall velocity by one of the three methods, namely

(a) application of laws of gravity settling in the appropriate ranges,

(b) method of Pinchbeck and Popper[9] using the equation

$$Re_t = -6 + \sqrt{36 + \tfrac{4}{3}\, g\, (\rho_s - \rho_f)\, \rho_f\, d_p^3/\mu^2}\ , \quad \text{and} \qquad \ldots\ \ldots\ (1.4)$$

(c) plots of $C_d \cdot Re^2$ vs. Re where,

$$C_d\, Re^2 = \left[4\, g\, \rho_f\, d_p^3\, (\rho_s - \rho_f) \right] / (3\mu^2) \qquad \ldots\ \ldots\ (1.5)$$

$$\text{and} \quad Re = \frac{d_p\, u_t\, \rho_f}{\mu} \qquad \ldots\ \ldots\ (1.6)$$

For gas-solid system, Fan et.al[6] compared the maximum semi-fluidization velocity (obtained by extrapolation of h_{pa}/h_s vs. G plot to $h_{pa}/h_s = 1.0$) with the terminal free fall velocity of the particles. They have calculated the terminal settling velocity and have also determined it experimentally for all the particles. The values are given in Table 1.A.

TABLE-1.A

-Comparison of maximum semi-fluidization velocity as obtained by Fan et.el.[6] in a 4-inch column-

Particles	Max. Semi-fluidization velocity, lb/hr.ft2		
	Calculated, G_t	Extrapolated G_t	Observed G_t''
1. 80-100 mesh glass beads	1200	1450	2064
2. Polyethylene sphere segments	3380	3850	3776
3. Polyethylene Cylinders	5250	5600	5488

As can be seen from Table l.A the calculated values are lower than those obtained by extrapolation. The reasons attributed to this discrepancy are as follows:

(i) The assumption of the fact that, the initial static bed porosity is equal to the packed bed porosity of a semifluidized bed is not correct. Moreover, the complete formation of packed bed at the top, is not achieved experimentally. Hence the velocity obtained by extrapolation of the curve to $h_{pa}/h_s = 1.0$, is higher.

(ii) The size distribution of particles also affects the value of the maximum semi-fluidization velocity. Larger particles have higher terminal velocities, but the calculation is on the basis of the average particle size. So the calculated values will be smaller than the extrapolated ones which were evaluated when all the particles including the larger ones, were transported from the fluidized section to the packed section.

(iii) It is well known that the fluid along the axis of the column moves faster than the fluid adjacent to the wall, and hence the particles near the wall may be falling downwards while the particles along the center line of the colum are still held in suspension.

For liquid-solid semi-fluidization of spherical as well as non-spherical particles, Roy and Sarma[18], calculated the maximum semi-fluidization velocity by the application of the gravity settling law and compared this with the values obtained by (i) extrapolation of the expanded bed voidage vs. fluid velocity plot to $\epsilon_f = 1.0$ and (ii) extrapolation of h_{pa}/h_s vs. G curve to $h_{pa}/h_s=1.0$.

Observations similar to that of Fan et.el, were also made by the authors. On the basis of their experimental data, they have suggested an equation for the prediction of the maximum semi-fluidization velocity from a knowledge of the physical properties of the system only. The equation is

$$G_{msf} = 0.3\,(Ar)^{0.58}\left(\frac{\mu}{d_p}\right) \quad .. \quad .. \quad (1.7)$$

Based on the above equation, a nomograph has also been suggested by the authors[22]

Poddar and Dutt[10] have given the following equation for the prediction of the maximum semi-fluidization velocity in liquid-solid

$$18\,Re_{msf} + 2.7\,Re_{msf}^{1.687} = Ga \quad .. \quad .. \quad (1.8)$$

where, $$Re_{msf} = \frac{d_p\,G_{msf}}{\mu} \quad .. \quad .. \quad (1.9)$$

In a later work the authors tried to correlate the maximum semi-fluidization velocity as calculated above with the minimum fluidization obtained from a generalised equation proposed by Wen and Yu[25]

$$Re_{mf} = \left[(33.7)^2 + 0.0408\,Ga\right]^{0.5} - 33.7 \quad .. \quad .. (1.10)$$

From equations (1.8) and (1.10) the final relation between the minimum fluidization and the maximum semi-fluidization velocities as derived by them is,[12]

$$\frac{18\,Re_{msf} + 2.7\,Re_{msf}^{1.687}}{Re_{mf}} = \alpha + \sqrt{\alpha^2 + \beta\,Ga} \quad .. \quad .. \quad (1.11)$$

where, $\alpha = 826$ and $\beta = 24.51$

II. PREDICTION OF PACKED BED HEIGHT IN SEMI-FLUIDIZATION:

Fan and coworkers[5] proposed an equation for the prediction of packed bed height from the maximum semi-fluidization velocity and the minimum fluidization velocity, for both gas-solid and liquid-solid systems[5,6]. The equation is -

$$f \left(\frac{h - h_s}{h - h_{pa}} , \frac{G_{sf} - G_{mf}}{G_t - G_{mf}} \right) = 0 \qquad \text{.. .. (1.12)}$$

i.e. when $h-h_s/h-h_{pa}$ is plotted against $(G_{sf}-G_{mf})/(G_t-G_{mf})$ log-log graph, a straight line is obtained. In this case G_t values may be either calculated or obtained from extrapolation, and G_{mf} is to be calculated using Leva's equation -

$$G_{mf} = 688 \, \frac{d_p^{1.82} \left[\rho_f \left(\rho_s - \rho_f \right) \right]^{0.94}}{\mu^{0.88}} \qquad \text{.. .. (1.13)}$$

In addition Fan and coworkers[5] suggested an all together different method for the prediction of packed bed formation. The following assumptions of Richardson and Zaki[15] were assumed to be valid.

(i) The particles are uniformly distributed in the fluidized bed,

(ii) The movement of particles in suspension is completely independent of other particles, and also under their own assumption that the formation of packed bed does not change the average particle distance in the"fluidizing section, and,

(iii) The voidage of packed bed is constant and is equal to that of least dense static bed under resting conditions.

Based on the above considerations, they developed the following equations :

For packed bed formation,

$$h_{pa} = (h_f - h) \frac{(1 - \epsilon_f)}{\epsilon_f - \epsilon_{pa}} \qquad .. \quad .. \quad (1.14)$$

The weight fraction (X) of total solid distributed in the packed bed is given by -

$$X = \frac{A \rho_s (1 - \epsilon_{pa}) h_{pa}}{W} = \frac{(1- \epsilon_{pa})(h_f-h)}{h_f (\epsilon_f - \epsilon_{pa})} \quad .. \quad (1.15)$$

The observed and calculated values of the packed bed formation tallied well upto a value of $\epsilon_f = 0.8$.

The equation proposed by Poddar and Dutta[11] for the formation of packed bed is -

$$h_{pa} = \frac{h_s (1 - \epsilon_{pa})}{\epsilon_f - \epsilon_{pa}} - \frac{h_f (1 - \epsilon_f)}{\epsilon_f - \epsilon_{pa}} \quad .. \quad .. \quad (1.16)$$

where ϵ_f can be related as -

$$\epsilon_f = \left[\frac{18 \text{ Re} + 2.7 \text{ Re}^{1.687}}{\text{Ga}} \right]^{0.2125} \quad .. \quad .. \quad (1.17)$$

Roy and Sarma [19] have introduced the minimum semi-fluidization velocity term in place of the minimum fluidization velocity in equation (1.12) of Fan et. el. and developed an expression which may be written as -

$$\frac{h - h_s}{h - h_{pa}} = \left(\frac{G_{sf} - G_{osf}}{G_{msf} - G_{osf}}\right)^{0.2} \qquad .. \quad .. \quad (1.18)$$

Another dimensional equation for the direct prediction of packed bed formation in liquid-solid system has been proposed by the same authors[20] as -

$$h_{pa} = 8 \times 10^{-3} (G_{sf} - G_{osf})^{0.58} \quad .. \quad .. \quad (1.19)$$

where, h_{pa} is in inches.

An indirect relationship for packed bed formation was suggested by Sunkoori and Kaparthi[23].The ratio of the free surfaces during free and restricted fluidizations (semi-fluidization)was related with the fluid mass velocity and the particle size as,

$$\left(\frac{h_f}{h'}\right) d_p^2 = A. e^{0.1G} \quad .. \quad .. \quad (1.20)$$

where, A is a function of (h/h_s) which can be expressed in the form,

$$A = 0.007 (h/h_s)^{2.5} \quad .. \quad .. \quad (1.21)$$

A phase diagram showing the regions of restricted packed bed, fluidized bed and semi-fluidized bed was also presented by them by plotting the variation of bed height with fluid mass velocity. In addition,a plot of modified friction factor(f_m) against particle Reynolds number (Re_p) was suggested and the data were found to fit well for all the above cases.

PREDICTION OF TOTAL PRESSURE DROP.

Measurements of total pressure drop occuring in semi-fluidization have been first reported by Fan et. el.[6] and these measured values have been compared with those calculated from theoretical equations (Table-1.B).

TABLE -1.B.

Calculated and observed overall pressure drops in semi-fluidized bed(6)

Particles	d_p, ft.	G, $lb/hr.ft^2$	ΔP_t inches of Hg. Observed	Calculated by eq.^{n} (1.22)	Calculated by eq.^{n} (1.25)
1. 80-100 glass beds	0.000508	451.1	23.2	21.60	9.89
2. Polyethylene sphere segments	0.004740	1550.0	5.5	6.30	3.18
3. Polyethylene cylinders	0.009350	1483.5	2.4	2.54	1.92

In case of semi-fluidization, the total pressure drop should be ideally the algebraic sum of the pressure drops across the fluidized section and packed section, as both are aligned in series in the direction of flow. Hence,

$$\Delta P_t = \left(\frac{\Delta P}{L}\right)_f (h - h_{pa}) + \left(\frac{\Delta P}{L}\right)_{pa} \cdot h_{pa} \quad \ldots \quad ..(1.22)$$

For fluidized section,

$$\left(\frac{\Delta P}{L}\right)_f = (1 - \epsilon_f)\ (\rho_s - \rho_f) \quad .. \quad .. \quad (1.23)$$

For packed section, using Ergun's equation,

$$\left(\frac{\Delta P}{L}\right)_{pa} = \frac{1}{g_c}\left[150\frac{(1 - \epsilon_{pa})^2}{\epsilon_{pa}^3}\ \frac{\mu\, u}{d_p^2} + 1.75\frac{(1 - \epsilon_{pa})}{\epsilon_{pa}^3}\ \frac{G\ u}{d_p}\right] \quad .. \quad .. \quad (1.24)$$

$$\text{So,} \quad \Delta P_t = \left(\frac{\Delta P}{L}\right)_{pa} \cdot h_{pa} + \left(\frac{\Delta P}{L}\right)_f (h - h_{pa})$$

$$= \left[150 \frac{(1-\epsilon_{pa})^2}{\epsilon_{pa}^3} \frac{\mu u}{d_p^2} + 1.75 \frac{(1-\epsilon_{pa})}{\epsilon_{pa}^3} \cdot \frac{G u}{d_p} \right]$$

$$\left[(h_f - h) \frac{(1-\epsilon_f)}{\epsilon_f - \epsilon_{pa}} \right] \frac{1}{g_c}$$

$$+ \left[h_f - \frac{(1-\epsilon_{pa})(h_f - h)}{\epsilon_f - \epsilon_{pa}} \right] (1-\epsilon_f)(\rho_s - \rho_f) \qquad \ldots \ldots (1.25)$$

Fan and coworkers measured the pressure drop in fixed and fluidized beds separately and the total pressure drop was obtained using equation (1.22). This has been compared with the observed bed pressure drop and also with that calculated using equation (1.25). It can be seen that the experimental values are nearer to those calculated by using equation (1.22), whereas, equation (1.25) gave lower values. The authors explained the deviations as due to the difficulty in using equation (1.25) which involves the determination of packed and fluidised bed porosities accurately. Further, the assumption in equation (1.14), i.e. $\epsilon_{pa} = \epsilon_o$ is not very accurate, because the top bed is under compression due to the upward movement of the fluid. This results in the variation of packed bed porosity and Ergun's equation is too sensitive to this variation.

Based on their experimental data for liquid-solid system, Roy and Sarma[21] have presented an equation of the following type for the prediction of pressure drop in a semi-fluidized bed:

$$\frac{G_{sf}}{G_{msf}} = C \left[\frac{\Delta p}{h_s \rho_s} \right]^{0.28} \qquad \text{.. .. (1.26)}$$

where C is dependent on the physical properties of the system.

STUDIES ON HEAT TRANSFER, MASS TRANSFER AND REACTION KINETICS.

(a) Heat Transfer:

The only heat transfer study made so far was reported by Rao and Kaparthi.[13] They have investigated wall-to-fluid heat transfer in semifluidized beds using air as the medium. An equation relating the heat transfer coefficient was suggested as,

$$Nu_p = 0.72 \; (Re_p)^{1.1} \left(\frac{1-\epsilon}{\epsilon}\right)^{0.4} \qquad \text{.. .. (1.27)}$$

The voidage, as used in this equation refers to fluidization and this limits the applicability of such work.

(b) Mass Transfer:

Investigations in the field of semi-fluidization were started by Wen and coworkers[4] with mass transfer studies. Experiments were conducted with benzoic acid- water system in semifluidized beds. The mass transfer data were correleted in terms of J_d-factor and modified Reynolds number. The mass transfer coefficients were calculated on the basis of overall log mean driving forces for both packed and fluidized beds. The expression for benzoic acid-water system was -

$$J_d = 1.865 \; (Re_m)^{-0.48} \qquad \text{.. .. (1.28)}$$

for $5 < Re_p < 30$.

In order to determine the effect of bed expansion, the mass transfer coefficients, under approximately constant operating conditions, were plotted against the expansion ratios. A linear relationship was observed in all such cases. In summarising their work the authors made the following comments:

(i) For a given fluid-flow rate a desired mass transfer coefficient can be selected by adjusting the top sieve plate.

(ii) The values of mass transfer coefficient for semifluidized bed lie between the limits of fixed and fluidized bed values.

(iii) For a given expansion ratio, the mass transfer coefficient was found to increase as the fluid flow rate is increased.

In a recent communication Tripathi and coworkers[14] have presented results of studies of particle-to-fluid mass transfer in semifluidized beds with benzoic acid- , cinnamic acid- and 2-naphthol-water systems.The following correlations have' been suggested for J_d factor in terms of particle Reynolds number :

For benzoic acid,

$$J_d = 2.743\,(Re_p)^{-0.484} \qquad \ldots \quad \ldots (1.29)$$

For cinnamic acid,

$$J_d = 2.35\,(Re_p)^{-0.484} \qquad \ldots \quad \ldots (1.30)$$

For 2-naphthol,

$$J_d = 1.865\,(Re_p)^{-0.484} \qquad \ldots \quad \ldots (1.31)$$

The authors concluded that the variation in the transfer rates is not only due to the difference in the diffusion coefficients of the solutes, but also due to the degree of compression of particles in the semifluidized state.

(c) Reaction Kinetics:

Cholette and Blanchet[3] have shown that a combination of mixed and tubular reactors (MT reactors) is very often more efficient than either of these reactors operated independently. This is specially so in exothermal reactions where an optimum performance may be obtained with MT reactors. The theoretical advantage of the MT combination can be practically realized in a simple reactor system utilizing the principle of semi-fluidization. With this end in view Babu Rao and Doraiswamy[1] initiated their work on the development of a semi-fluidized MT reactor. Incidentally, they conducted experiments on gas-soild semi-fluidization. The authors introduced a new dimensionless group called the semi-fluidization group (S_f), which along with Archimedes number (Ar) have been correlated against the ratio of semi-fluidization velocity to terminal velocity,

$$\frac{G_{sf}}{G_t} = K\,(Ar)^a\,(S_f)^b$$

$$= K\,(Ar)^{-0.15}\,(S_f)^{-0.186} \qquad \ldots\ \ldots\ (1.32)$$

where,

$$= K = 17.3/D^{0.372} \quad (D \text{ is in ft}) \qquad \ldots\ \ldots\ (1.33)$$

From the foregoing discussions it can be seen that the technique of semi-fluidization is a developing and promising one. While a good amount of work have been reported on momentum transfer studies in liquid-solid systems, scanty informations are available on gas-solid semi-fluidization. Some aspects of this operation like the direct prediction of minimum and maximum semi-fluidization velocities, determination of pressure drop across the bed and hence the power requirement to sustain such a bed, are yet to be explored. It can further be seen that all the system parameters have not been exhaustively studied by any author. In the field of heat transfer only one work is reported, whereas mass transfer operation has been restricted to a limited number of liquid-solid systems. Also development work for evolving newer processes based on this technique has to go a long way. It is practically a virgin field and the present work is a step forward to meet with this requirement.

CHAPTER- II

EXPERIMENTAL ASPECTS.

EXPERIMENTAL ASPECTS

EXPERIMENTAL SET-UP

The experimental set-up consists primarily of the following major components (fig. 2.1) :

1. Air compressor
2. Air accumulator
3. Orifice meter with an ¼" orifice plate.
4. Conical air distributor fitted with a 150 mesh stainless steel screen
5. 45 mm. i.d. perspex tube of 57 cm. in length (semifluidizer)
6. A movable restraint made of a porous brass plate and a brass screen of 80 mesh both soldered to a brass cone and rigidly fixed to a 3/16" dia. mild steel rod extending to the top of the semi-fluidizer. By lowering or raising this rod, the restraint position can be varied.
7. Pressure gauge.
8. Quick opening valve.
9. Manometer panel board.
10. Supporting structure.

Air compressor :

It is a multi-stage water cooled air compressor of sufficient capacity.

1 & 3	MANOMETERS FOR ORIFICE METER	11	ORIFICE METER
2 & 4	MANOMETERS FOR BED	12	RESERVOIR
5	SEMI-FLUIDIZER	13	COMPRESSOR
6	MOVABLE RESTRAINT ASSEMBLY	14	STRUCTURE
7	TOP RESTRAINT	15	BASE PLATE SUPPORT
8	INCLINED FEEDER	16	CLAMP
9	DISTRIBUTOR	17	MANOMETER PANEL BOARD
10	FLEXIBLE CONNECTION	18	LINE PRESSURE GAUGE
		19	RESERVOIR PRESSURE GAUGE

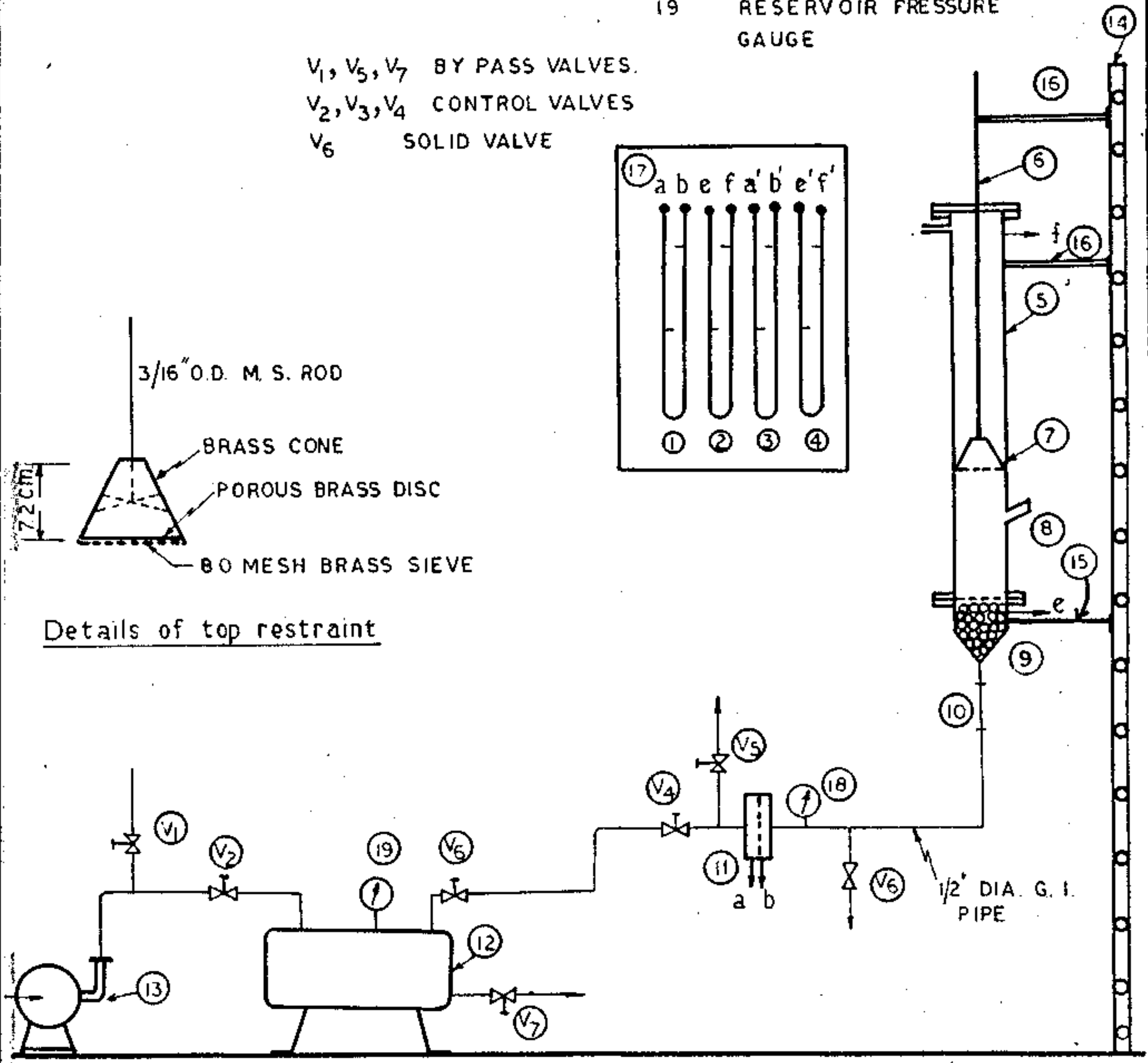

FIG. 2.1 SCHEMATIC DIAGRAM OF THE EXPERIMENTAL SET-UP.

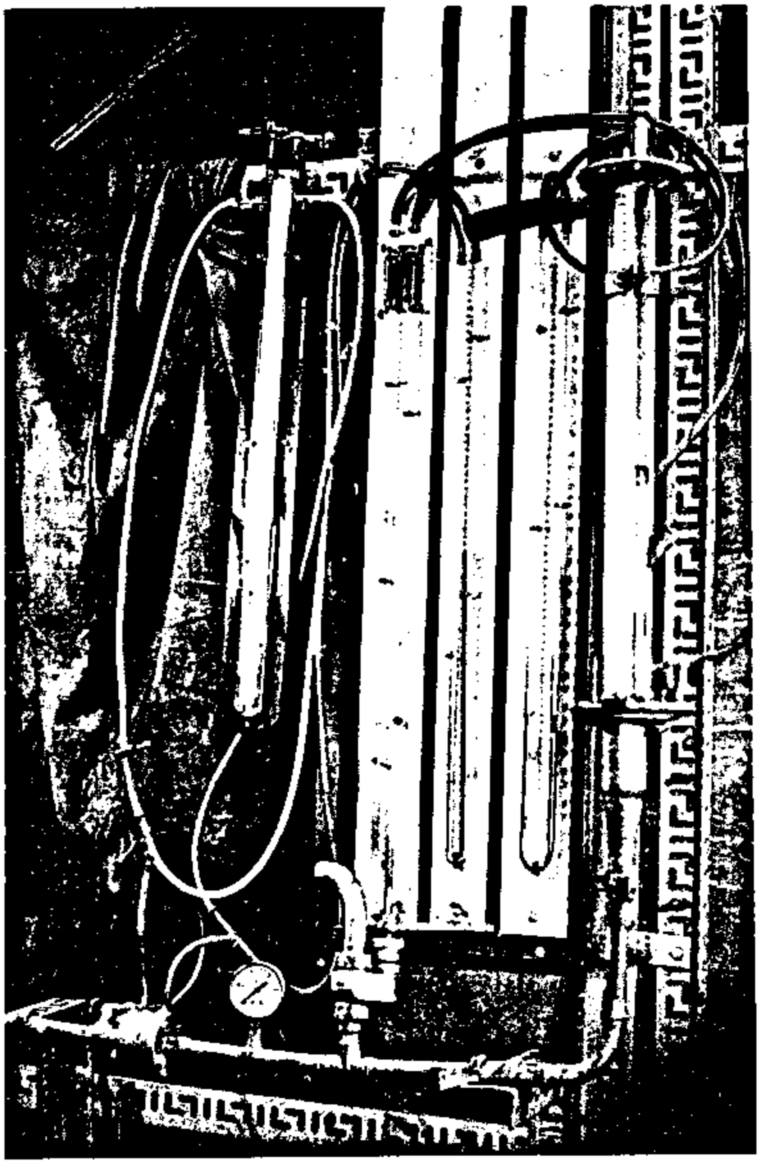

PLATE-1
EXPERIMENTAL SET-UP

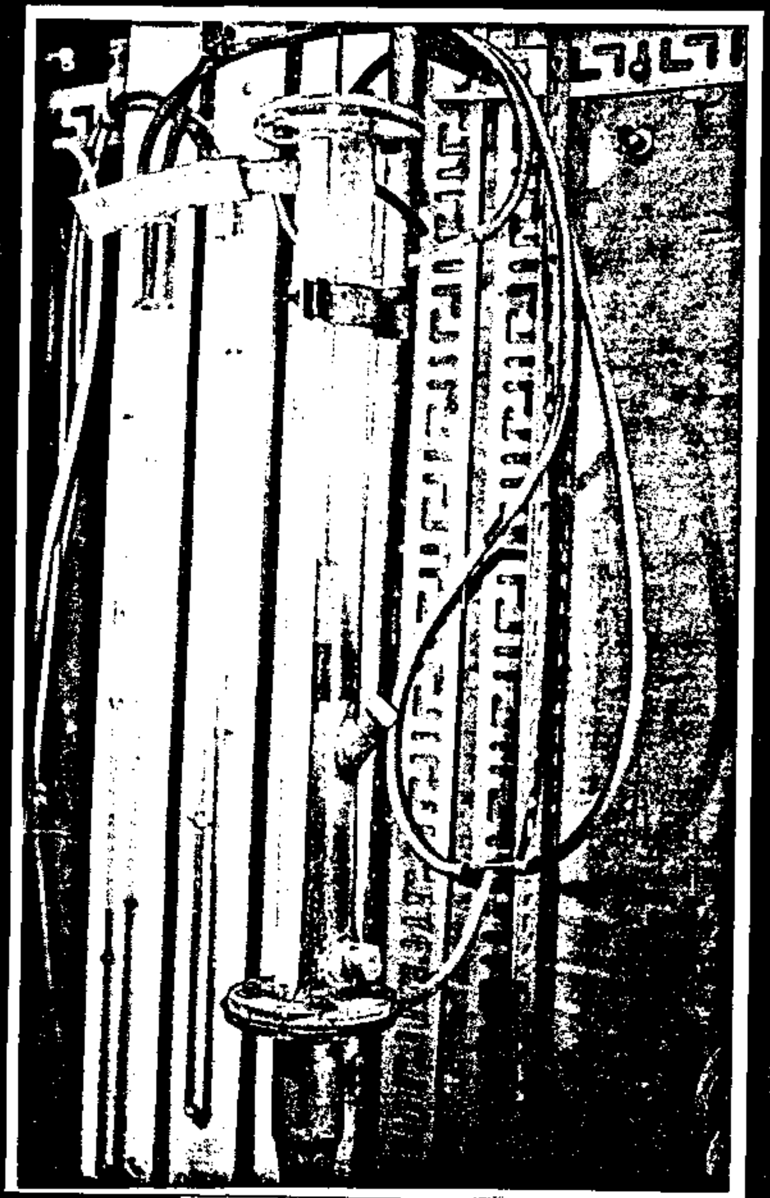

PLATE-2
SEMIFLUIDIZER

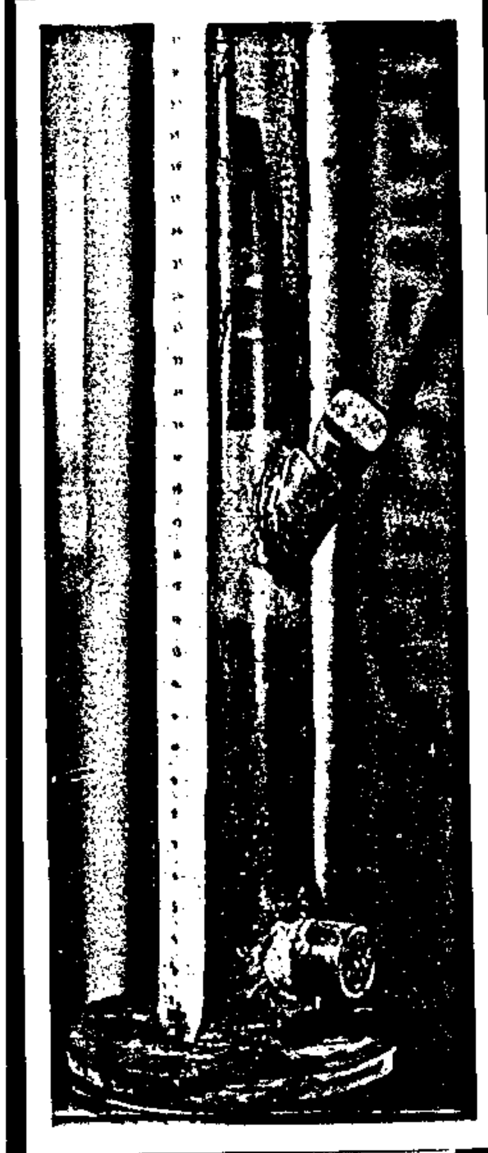

PLATE-3
SEMIFLUIDIZED BED

Air accumulator :

It is a horizontal cylinder used for storing the compressed air from compressor. There is one 3/4" G.I. pipe inlet to the accumulator and one by-pass (1/2″ G.I.) from one the end of the cylinder. The exit line is also of 1/2″ G.I. pipe taken from the central part of the cylinder. The purpose of using an air accumulator in the line is to dampen the pressure fluctuations. The accumulator is also fitted with a pressure gauge. The operating pressure in the cylinder is kept at 20 psig.

Orificemeter:

The orificemeter is made of two flanges of 76 mm. O.d. fitted with four bolts of 8 mm. diameter. Inside the two flanges, there is an orifice plate of 6.-5 mm. bore. The plate is made of mild steel and one end of it is counter-sunked and the entrance is sharp-edged. The pressure tappings are made within the flanges.

Pressure gauge:

A pressure gauge of the range 1-50 psig is in the line after orificemeter .

Quick opening valve :

A quick opening valve of 3/4" i.d. is attached next to the " pressure gauge for sudden release of line pressure.

Air distributor :

This is an important component of the experimental- set-up. It* consists of a cylindrical portion (4.5 cm. i.d. x 7.5 cm. length) followed by a conical bottom. The cone angle is about 35-40 . The larger end is of 45 mm. i.d. and the smaller end of 12 mm. i.d., the height of the cone being 6.5 cms. The cone is brazed with a G.I. flange of 11.4 cms. o.d. The central bore in the flange is also of 45 mm. diameter. The cone is made of ordinary G.I. sheet. The inside hollow space of the distributor is filled with 3 mm. dia speherical glass beads for uniform distribution of air. The beads are supported over a coarse screen at the bottom.

Semifluidizer:

The semofluidizer consists of a 4.5 cm. i.d. and 57 cm. length transparent perspex column, both ends being fixed to perspex flanges. All the flanges have 4 bolt holes' of 1/4" dia. and of thickness 5/16" . Two pressure tappings are provided for noting the bed pressure drop. There is an inclined feeder of 1.9 cm i.d. fitted with a wooden stopper(air-tight), attached to one side of the column at a convenient height, so that the smooth movement of the top restraint (both upward and downward) is not affected. The grid is made of 150 mesh stainless steel screen and is placed rigidly in-between the flanges.

Movable restraint:

This is the most important part of the semi-fluidization set-up in general, and the column, in particular. The success of the process depends on the suitable design of the restraint and its smooth movement along the inner wall of the column. At the same time care has to be taken to see that the restraint remains intact, making it completely air-tight (fig. 2.1). The hollow truncated cone is made of 1/32" thick brass sheet and to the lower end of it a brass plate having 1/32" dia holes, is soldered. To this plate is attached another 80 mesh brass screen. In order to make the restraint air-tight, a thin strip of rubber is fixed to the periphery of the truncated brass cone. The movement to the cone assembly is given with the help of a mild steel rod of 3/16" o.d., held in position in between four thin mild steel rods soldered to the outside cone surface. A portion of the rod projects to the outside of the column, which can be operated to push the restraint up or down to any convenient position. The rod can be fixed with respect to a particular position of the movable restraint, by means of a clamp at the top of the column.

Manometer panel board:

Two sets of manometers are arranged in this panel board, one set being used for the orifice pressure drop and the other for the bed. Each set consists of two manometers, one of which uses carbon tetrachloride (coloured) as the manometric liquid and the other mercury. The former records pressure drop in the lower range, while the latter for the higher ranges.

EXPERIMENTAL PROCEDURE :

The orificementer is calibrated first with the help of standard dry gas meter. The calibration charts are given in figs. 2.3(a and b) and 2.4 (a and b). Both volumetric and weight rate of flow of air have been plotted against the square root of the pressure drop with the help of the experimental data given in table 2.B_1 and 2.B_2. Physical properties of the fluid used in the experiments is given in Table 2.A.

A particular sample of material is introduced in-to the column and the bed height is noted . The movable restraint is adjusted for a definite bed expansion ratio. The air inlet valve to the semifluidizer is operated slowly, thus allowing the material to fluidize and to expand more and more in the column. The orifice and bed pressure drops are noted simultaneously for each rate of flow of air. As soon as the expanded bed of particles touch the top movable restraint, semi-fluidization sets in and bed formation starts. The height of the packed bed formed and the corresponding pressure drop are noted from time to time. At the end of each run, the position of the movable restraint is altered for a new bed expansion ratio. Addition of further amount of material is done through the inclined feeder. Removal of the material and charging of a fresh sample are carried out by opening the column. The room temperature is noted to account for the ambient temperature of the fluidizing medium in each run.

In order to determine the static and expanded bed porosities, a few experiments have been conducted. The static bed height and porosity were known by pouring a weighed amount of sample in the column. Later the same charge was fluidized and the bed expansions were noted for each flow rate, where from the expanded bed porisity is calculated.

AIR PERMEABILITY APPARATUS FOR THE DETERMINATION OF SURFACE AREA.

The determination of particle surface area is important, which is used for the calculation of the particle shape factor.

The surface area of the particles has been determined by air permeability method. The apparatus is shown in fig. 2.2. It consists

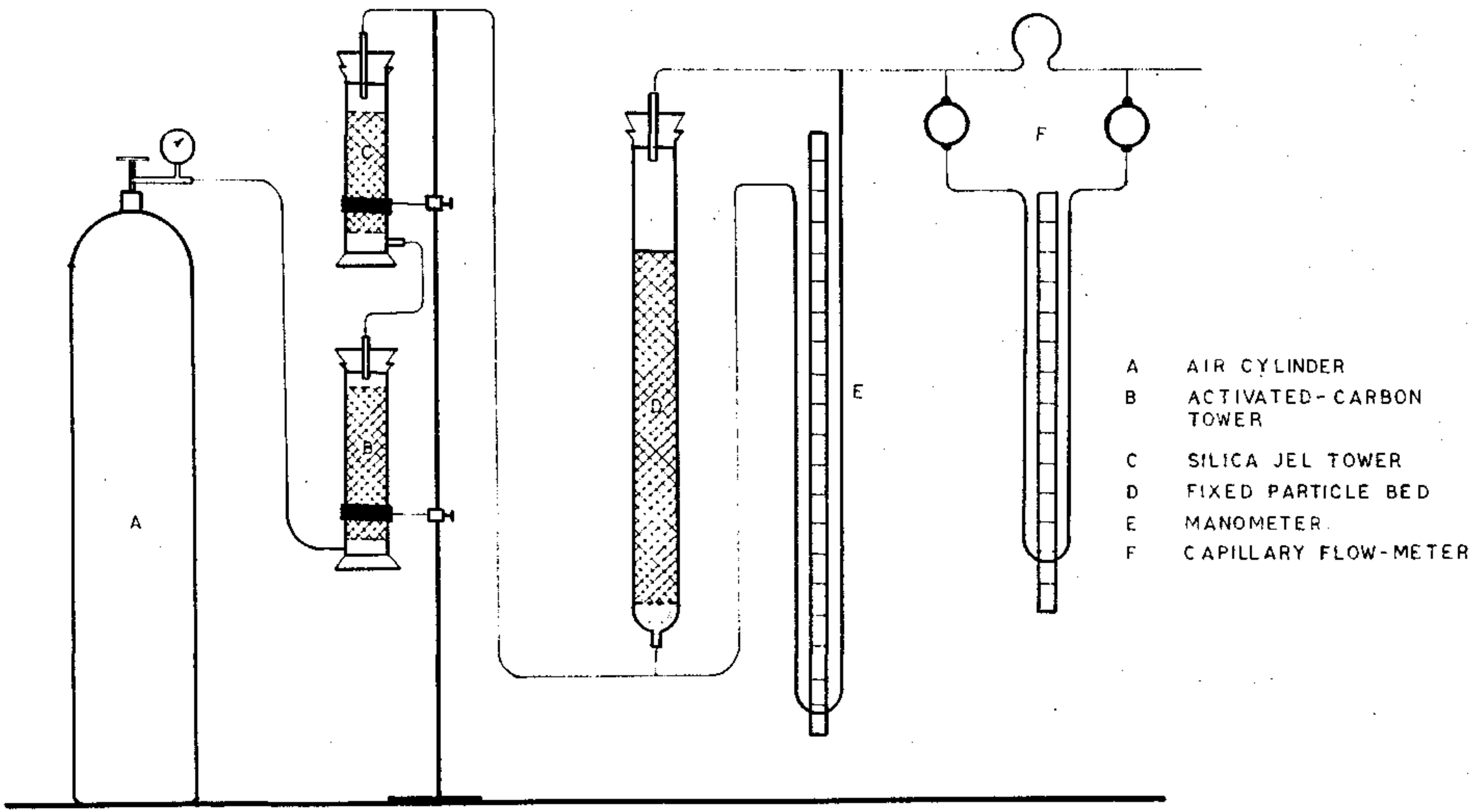

FIG. 2.2 AIR PERMEABILITY APPARATUS FOR DETERMINATION OF SURFACE AREA OF PARTICLES.

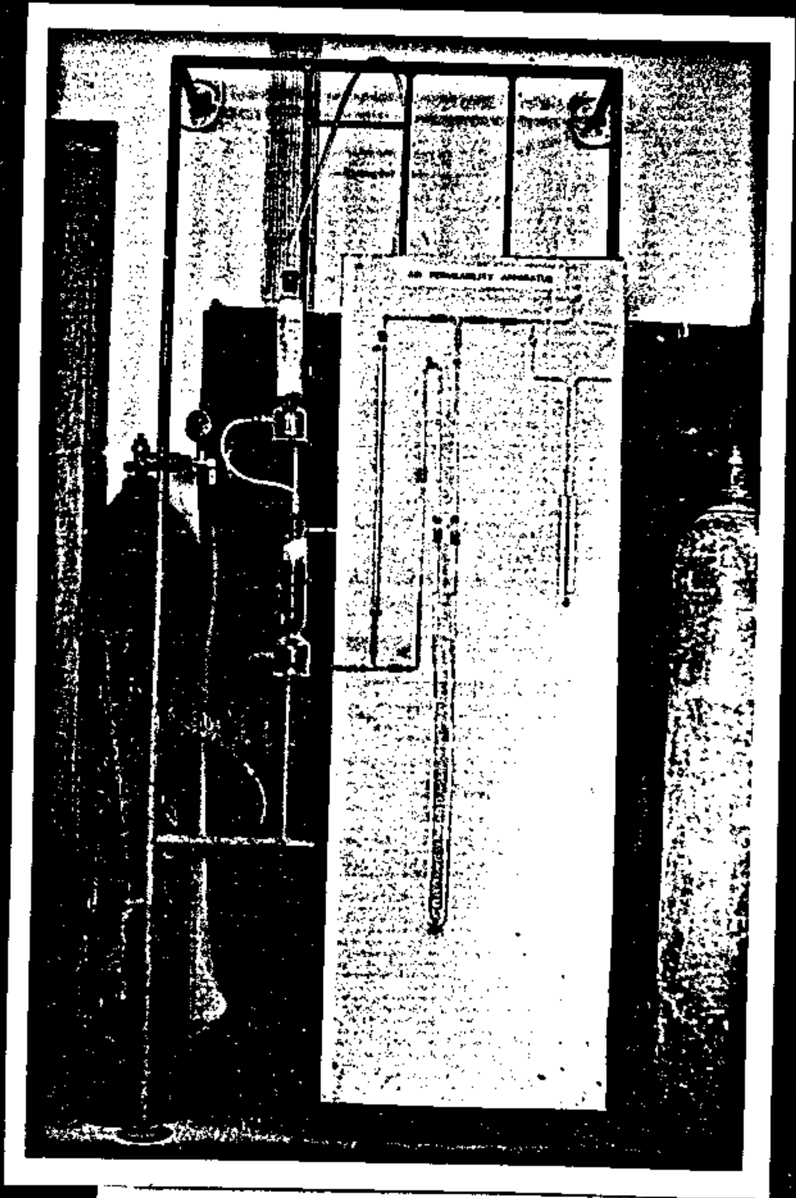

PLATE-4
AIR PERMEABILITY APPARATUS

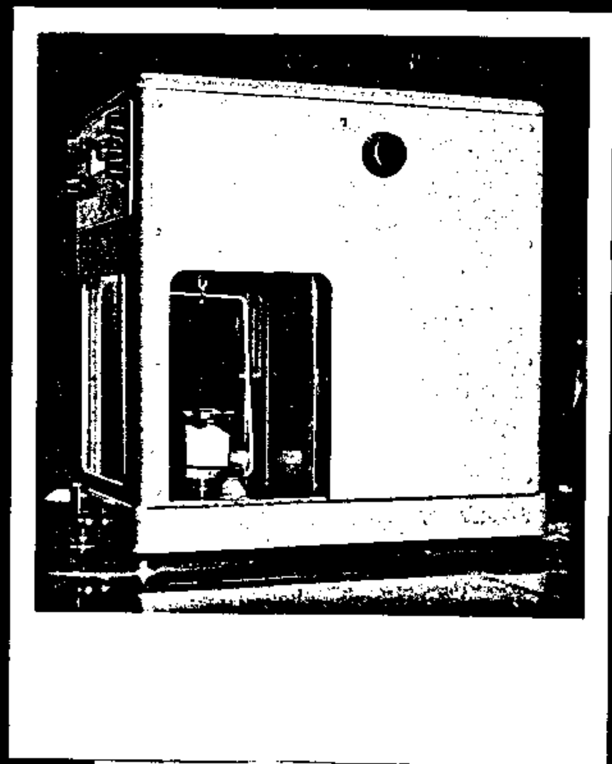

PLATE-5
METLER BALANCE

of an air cylinder. A, fitted with a pressure gauge and a needle valve to regulate the air flow rate. Air from the cylinder A, is passed through activated carbon bed, B, silica gel tower, C, and particle bed, D. The particle bed is contained in a long and narrow glass cylinder made of 50 cc burette. The pressure drop across the bed is measured with manometer, E. The air flow rate is measured with the capillary flowmeter, F (Plate no. 3).

Specific surface area per unit volume (S_v) is determined using Carman's pressure drop equation,

$$S_v = \frac{14}{(1 - \epsilon_{pa})L} \sqrt{\frac{\epsilon_{pa}(V_b)}{C} \times \frac{h_1}{h_2}} \quad \ldots\ldots (2.1)$$

where, ϵ_{pa} is the porosity of the bed (pore space volume per unit bed volume)

L is the height of the bed, cm.

V_b is the volume of the bed, cc.

C is the flowmeter constant

h_1 is the pressure drop across the bed, cm. and

h_2 is the pressure drop across the capillary flowmeter, cm.

The theoretical specific surface area (S_{th}) is given by

$$S_{th} = \frac{6}{d_{avg.}}$$

where, d_{avg} is the average particle diameter, cm.

DETERMINATION OF SURFACE AREA OF PARTICLES,.

About 50 to 60 grams of dried sample are charged to the glass cylinder. The sample is tightly packed down by gently tapping the sides of the cylinder until all large voids are eliminated and there is no further reduction in the bed volume. The bed height and the volume are recorded. Dry air is passed through the column and pressure drops across the bed (h_1) and capillary flowmeter(h_2) are noted. A few values of the pressure drops are recorded and an average pressure drop ratio is calculated. During the experiment, care is taken to maintain the bed height substantially constant.

TABLE-2.A

- PHYSICAL PROPERTIES OF FLUIDS USED -

Sl No	Fluid	Temperature °C	Density gm/cc.	Viscosity poise	Use
1	Air at 1 atm. pressure	22	0.0012	0.00018	Fluidizing medium
2.	Carbon tetra-chloride	22	1.585	-	Manometer liquid
3.	Mercury	22	13.600	-	Manometer liquid

TABLE-2.B_1

-Calibration Data for the Orificemeter-

Sl. No.	Manometer head: ΔH_2 (Cms of CCl_4)	Manometer head: $\sqrt{\Delta H_2}$ (Cms.)$^{\frac{1}{2}}$ of CCl_4	Air flow rate: Q, lit/hr.	Air flow rate: W Kg/hr.
1	0.6	0.775	340	0.41
2	1.8	1.340	640	0.77
3	4.2	2.050	972	1.17
4	6.5	2.550	1208	1.45
5	10.1	3.180	1510	1.81
6	14.6	3.820	1840	2.21
7	19.0	4.350	2125	2.55
8	24.0	5.900	2420	2.90
9	30.6	5.530	2790	3.34
10	36.5	6.040	3070	3.68
11	42.1	6.490	3300	3.96
12	47.5	6.900	3530	4.23
13	54.7	7.390	3830	4.60

TABLE -2.B_2

-Calibration Data for the Orificemeter-

Sl. No.	Manometer head: ΔH_2 (Cms. of Hg)	Manometer head: $\sqrt{\Delta H_2}$ (Cms.)$^{\frac{1}{2}}$ of Hg.	Air flow rate: Q lit/hr.	Air flow rate: W Kg/hr.
1	3.4	1.84	2790	3.34
2	4.0	2.00	3070	3.68
3	4.6	2.14	3300	3.96
4	5.3	2.30	3530	4.28
5	6.1	2.47	3830	4.60
6	7.5	2.74	4210	5.05
7	9.5	3.08	4750	5.70
8	13.4	3.66	5620	6.74
9	16.0	4.00	6050	7.25
10	17.3	4.16	6380	7.64
11	25.6	5.06	7500	9.00
12	30.3	5.50	8240	9.88
13	33.2	5.76	8700	10.42
14	36.5	6.04	9150	10.98
15	40.8	6.39	9650	11.57
16	46.0	6.78	10050	12.04
17	52.0	7.20	10730	12.87

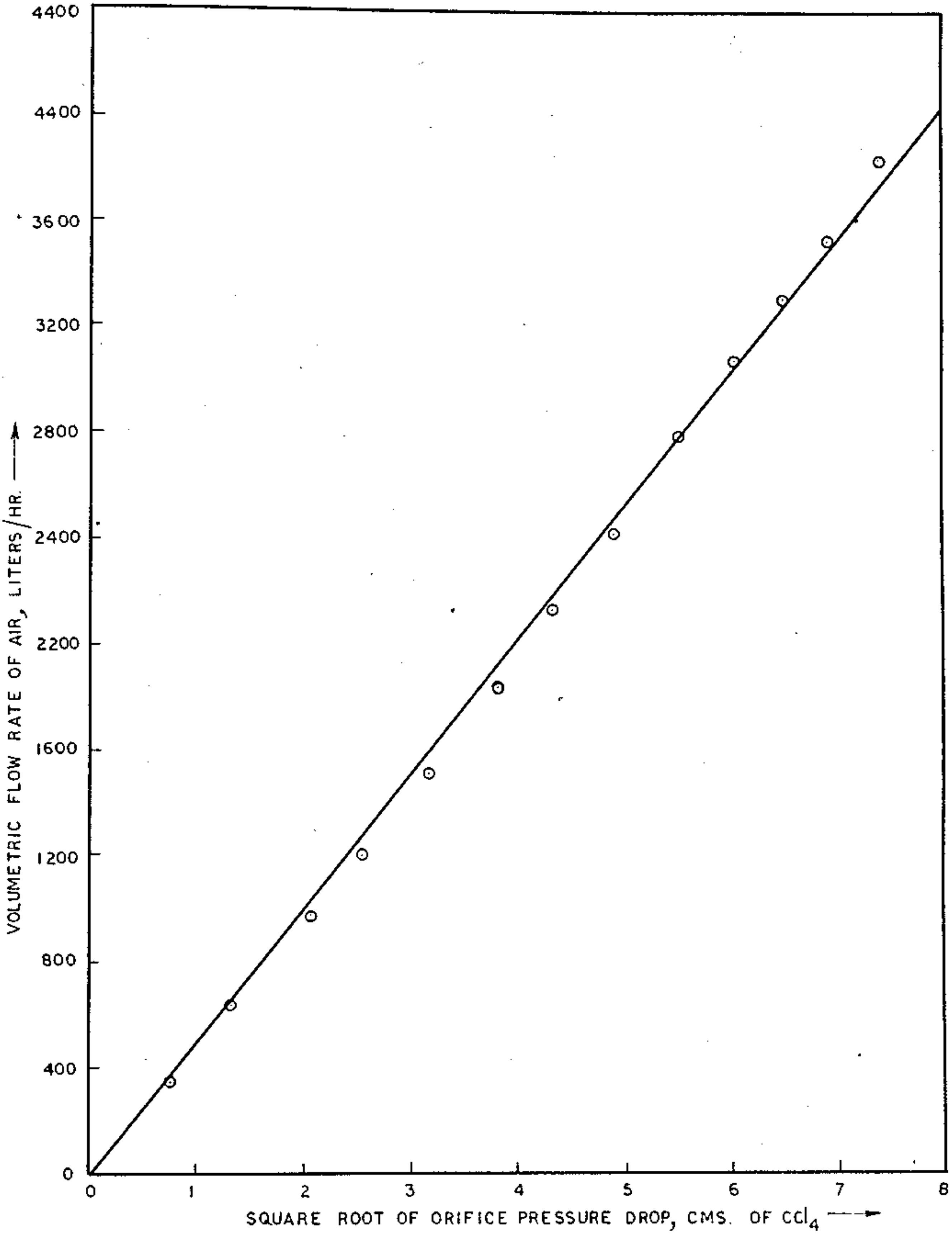

FIG.2.3a CALIBRATION CHART (VOLUMETRIC) FOR ORIFICEMETER

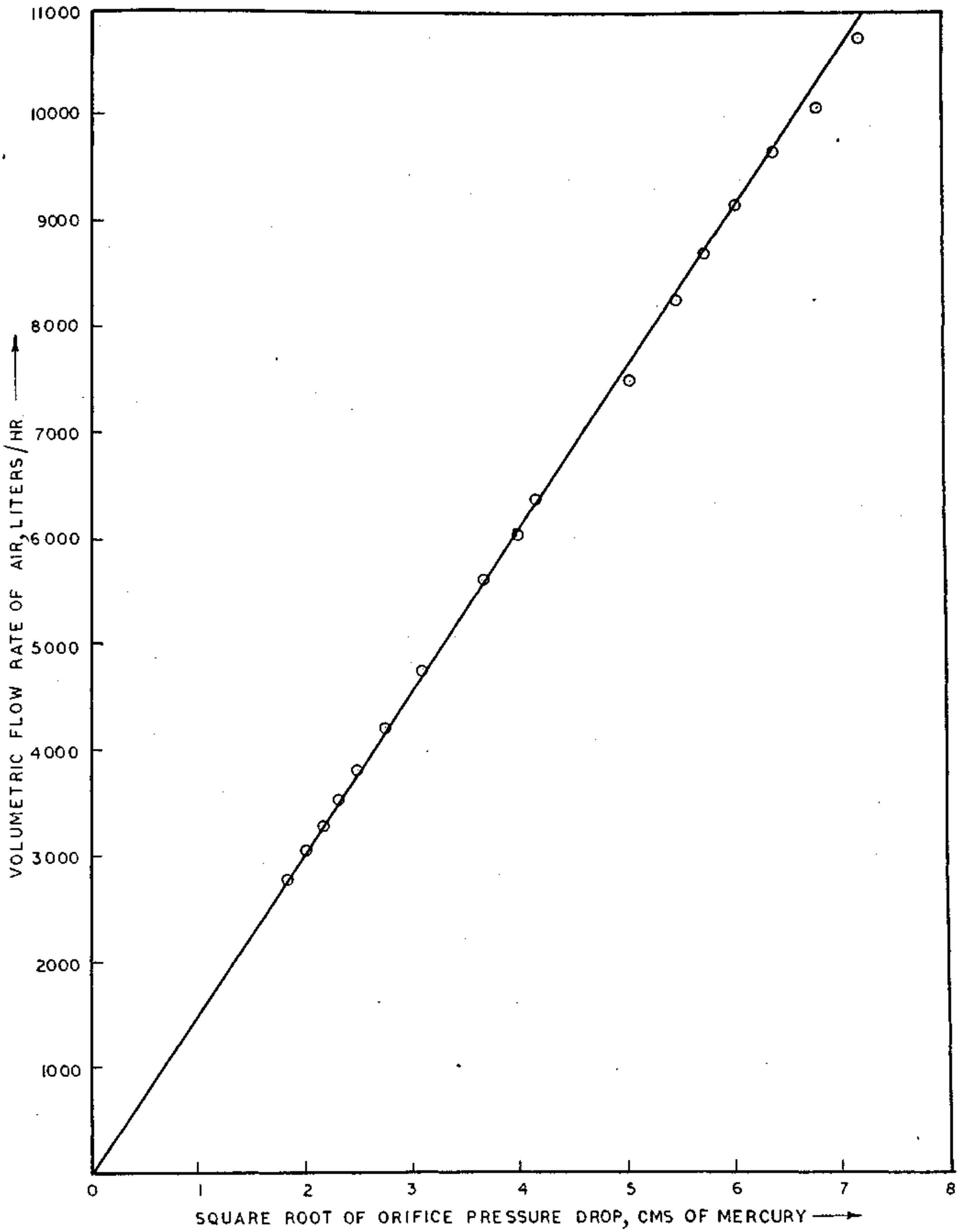

FIG.2.3 b CALIBRATION CHART (VOLUMETRIC) FOR ORIFICEMETER.

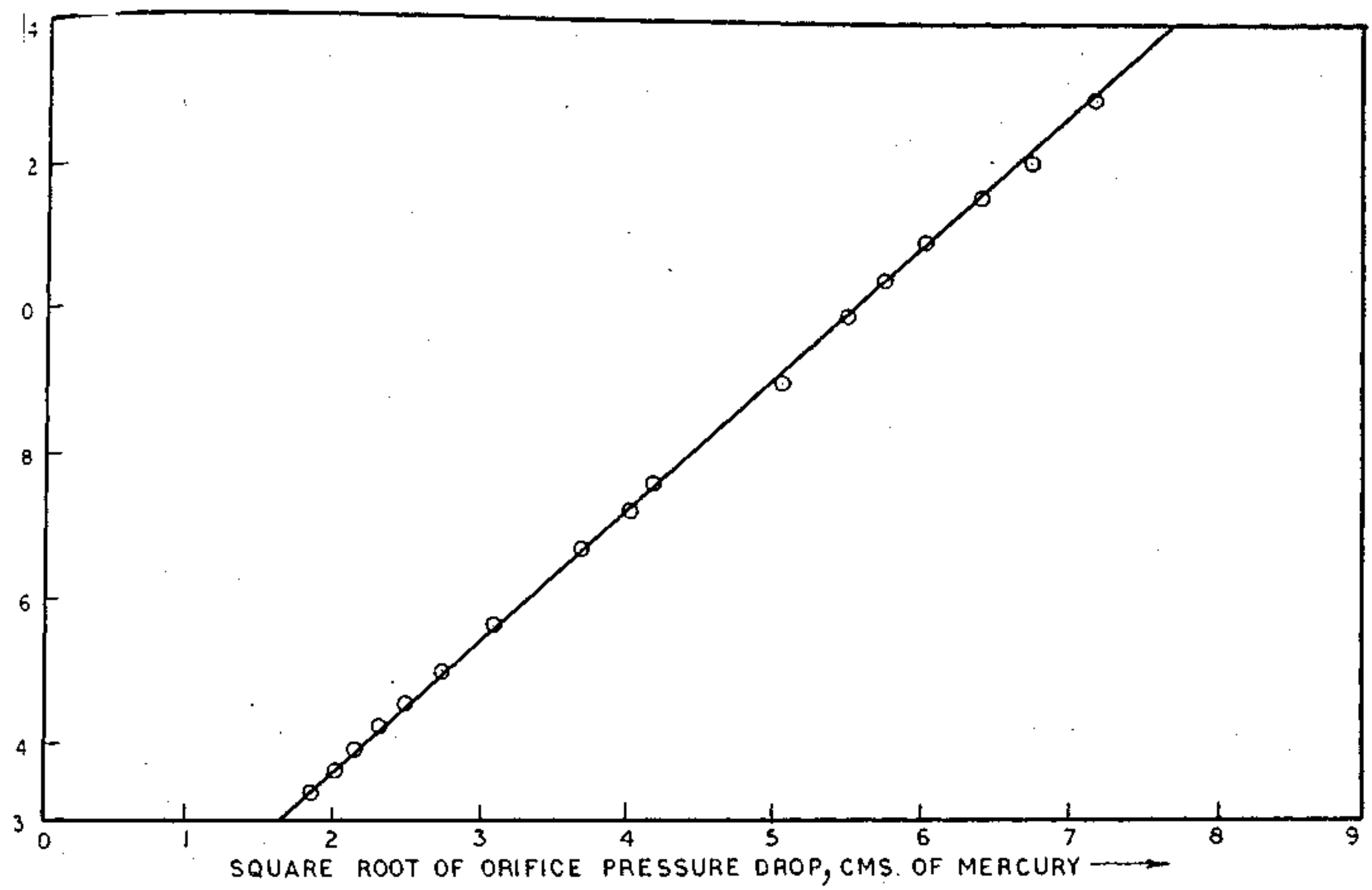

FIG.2.4 b CALIBRATION CHART (WEIGHT) FOR ORIFICEMETER.

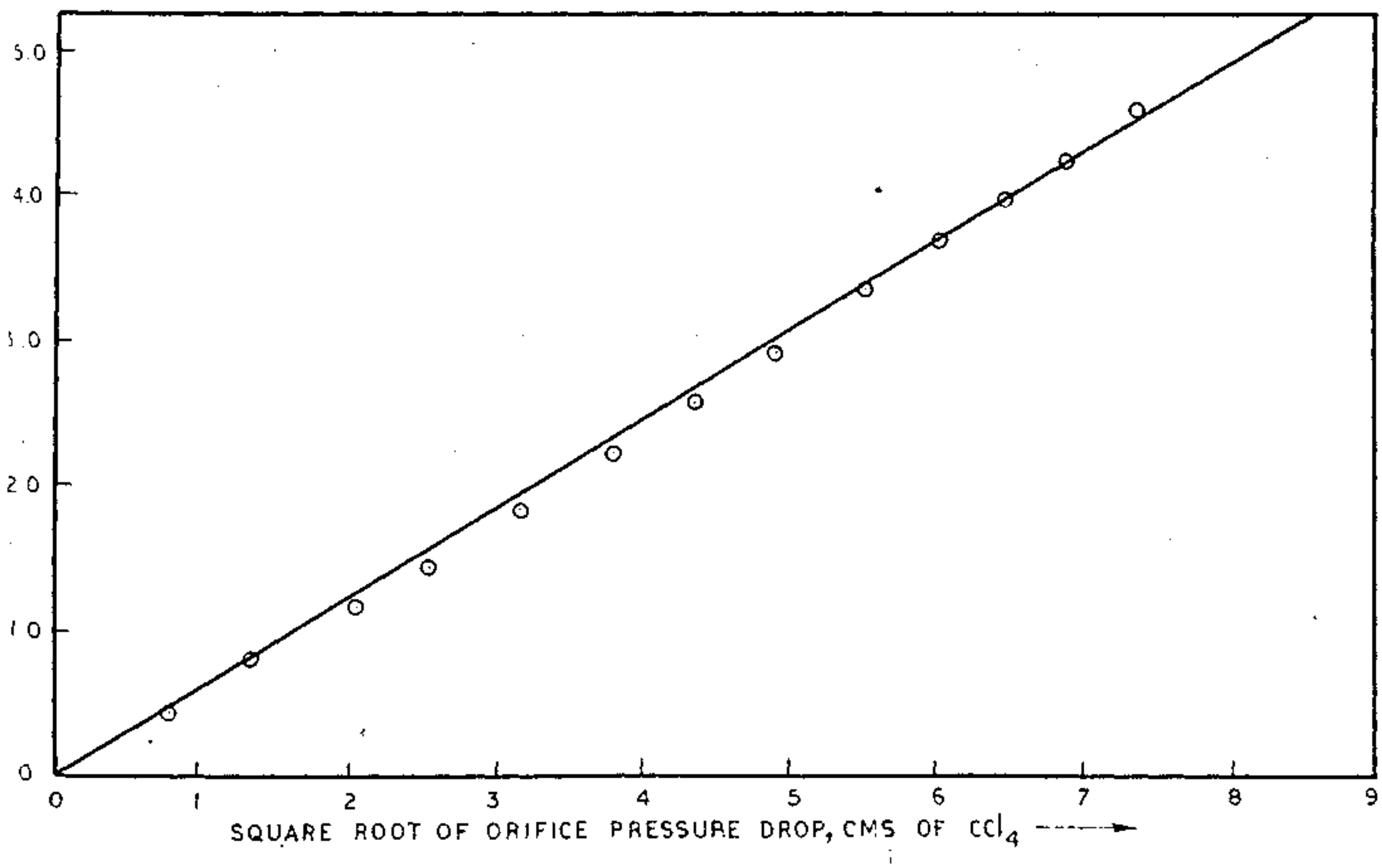

FIG.2.4a CALIBRATION CHART (WEIGHT) FOR ORIFICEMETER.

CHAPTER - III

DYNAMICS OF SEMI-FLUIDIZATION -I

A. Prediction of maximum semi-fluidization velocity:- Definition - methods of prediction; (a) extrapolation of h_{pa}/h_s vs G curve to $h_{pa}/h_s = 1.0$, (b) extrapolation of ϵ_f vs G curve to $\epsilon_f = 1.0$ -Effect of static bed height, bed expansion ratio, particle density and particle size on G_{msf} - correlation for prediction of G_{msf} from physical properties of the system- nomograph.

B. Prediction of minimum semi-fluidization velocity:- Definition - methods of prediction; (a) from ΔP vs G curve, (b) from ϵ_f vs h_f/h_s curve for h_f/h_s = R- effect of static bed height, bed expansion ratio, particle density and particle size on G_{osf} -correlation for the prediction of G_{osf}- nomograph.

C. Prediction of minimum semi-fluidization velocity from minimum fluidization velocity:- Prediction of minimum fluidization velocity-correlation for the ratio of minimum of semi-fluidization to minimum fluidization velocity as a function of system parameters.

DYNAMICS OF SEMI-FLUIDIZATION -I

Semi-fluidization characteristics of a bed are dependent on the static and dynamic properties of the system. The static properties include:

(a) Characteristics of solids like, particle size, particle density and sphericity,

(b) Fluid characteristics like density and viscosity,

(c) Equipment characteristics such as, the height, diameter and position of movable restraint.

The dynamic properties include mainly, the velocity of the fluid stream. Data on materials used and their semi-fluidization characteristics are given in Tables 3.A to 3.C .

A. MAXIMUM 'SEMI-FLUIDIZATION VELOCITY:

This is the velocity of fluid 'corresponding to which the entire bed of solid particles is transferred upwards to form a packed bed below the top restraint. In actual experiments, very often it is not possible to transfer the entire material to the top. However,there are two methods for the prediction of the maximum semi-fluidization velocity from extrapolation of the experimental data. These are :

i) extrapolation of h_{pa}/h_s value equal to unity from the plot of h_{pa}/h_s vs G (fig. 3.A_1 to 3.A_{14}).

ii) extrapolation of ε_f vs. G curve to a value of ε_f=1.0 (fig. 3.A_{15} to 3.A_{19}).

The values of the maximum semi-fluidization velocity obtained by the above two methods are given in Table 3.D.

T A B L E -3.A

-Physical Characteristics of materials used-

Sl. No.	Materials used	Particle size: mesh no. BSS	Particle size: Size, d_p cm.	Density gm/cc. ρ_s	Packed bed Porosity ϵ_{pa}	Surface area S_v $cm^2/cc.$	Sphericity Φ_s
Non-spherical							
1	Table salt	20/30	0.0751	2.100	0.596	241.0	0.331
2	Table salt	30/40	0.0442	2.100	0.588	300.5	0.452
3	Table salt	40/52	0.0338	2.100	0.560	302.0	0.587
4	Table salt	52/60	0.0274	2.100	0.533	335.0	0.654
5	Ammonium sulphate	30/40	0.0442	1.763	0.377	136.0	1.000
6.	Sand	30/40	0.0442	2.650	0.451	170.5	0.798
7	Magnesite	30/40	0.0442	2.800	0.443	177.0	0.770
Spherical							
8	Mustard seed	14/20	0.1105	1.120	0.362	54.2	1.000
9	Sago	14/20	0.1105	1.304	0.380	54.2	1.000

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT)WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_1

System: Salt-air Particle Size: 20/30 BSS

h_s = 9 cms. h = 18 cms. R =2.0 t=20°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.40 CCl_4	22.2	2.9 CCl_4	1.70 CCl_4	1.02	641	-	-
2	1.60 "	25.4	4.4 "	2.10 "	1.26	791	-	-
3	2.50 "	39.6	8.5 "	2.92 "	1.75	1100	-	-
4	3.80 "	60.3	17.6 "	4.20 "	2.53	1592	-	-
5	4.00 "	63.5	20.8 "	4.56 "	2.75	1730	-	-
6	4.20 "	66.6	33.9 "	5.82 "	3.52	2215	-	-
7	4.40 "	69.8	43.7 "	6.61 "	4.01	2520	-	-
8	4.60 "	73.0	6.1 Hg	2.47 Hg	4.44	2792	-	-
9	6.40 "	101.5	7.3 "	2.70 "	4.86	3080	1.5	0.166
10	10.10 "	160.0	11.6 "	3.40 "	6.12	3850	3.0	0.333
11	22.50 "	356.5	22.9 "	4.79 "	8.60	5410	5.0	0.555
12	33.00 "	523.0	29.3 "	5.41 "	9.74	6120	6.0	0.666

TABLE-3.B_2

System : Salt-air Particle Size : 20/30 BSS

h_s = 9cms. h = 22.5cms R =2.5 t=23°C

1	2	3	4	5	6	7	8	9
1	1.10 CCl_4	17.4	2.4 CCl_4	1.55 CCl_4	0.93	585	-	-
2	1.80 "	28.6	5.9 "	2.43 "	1.47	924	-	-
3	2.70 "	42.8	11.8 "	3.44 "	2.07	1302	-	-
4	3.85 "	61.0	20.4 "	4.51 "	2.73	1720	-	-
5	4.00 "	63.5	24.5 "	4.95 "	3.00	1887	-	-
6	4.20 "	66.6	34.2 "	5.85 "	3.55	2230	-	-
7	4.40 "	69.8	45.8 "	6.76 "	4.10	2580	-	-
8	4.60 "	73.0	5.8 Hg	2.41 Hg	4.33	2725	-	-
9	4.80 "	76.1	7.8 "	2.80 "	5.02	3160	-	-
10	6.10 "	96.7	9.8 "	3.13 "	5.65	3550	1.5	0.166
11	8.60 "	136.2	13.0 "	3.60 "	6.50	4090	3.0	0.333
12	18.20 "	288.5	27.2 "	5.21 "	9.40	5910	4.5	0.500
13	36.80 "	584.0	41.2 "	6.42 "	11.58	7275	6.0	0.666

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT)WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_3

System: Salt-air Particle Size: 20/30 BSS
h_s = 9 cms. h = 27 cms R =3.0 t=23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms ½	W Kg/hr	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.50 CCl_4	23.8	3.9 CCl_4	1.98 CCl_4	1.18	741	-	-
2	2.50 "	39.6	8.8 "	2.97 "	1.79	1125	-	-
3	3.50 "	55.5	14.7 "	3.84 "	2.31	1453	-	-
4	3.90 "	61.8	16.6 "	4.08 "	2.46	1547	-	-
5	4.20 "	66.6	28.8 "	5.36 "	3.25	2045	-	-
6	4.40 "	69.8	34.9 "	5.90 "	3.58	2250	-	-
7	4.60 "	73.0	6.3 Hg.	2.51 Hg.	4.52	2840	-	-
8	6.40 "	101.5	8.9 "	2.98 "	5.35	3365	-	-
9	9.10 "	144.2	12.2 "	3.49 "	6.28	3950	1.5	0.166
10	17.20 "	272.5	24.3 "	4.93 "	8.88	5590	3.0	0.333
11	25.60 "	405.5	33.8 "	5.81 "	10.48	6585	4.0	0.444
12	40.60 "	644.0	45.1 "	6.71 "	12.10	7600	5.0	0.555

TABLE-3.B_4

System: Salt-air Particle Size: 20/30 BSS
h_s = 9 cms. h =31.5 cms. R = 3.5 t = 25°C

1	2	3	4	5	6	7	8	9
1	1.70 CCl_4	26.9	3.6 CCl_4	1.90 CCl_4	1.15	723	-	-
2	3.50 "	55.5	11.2 "	3.34 "	2.01	1265	-	-
3	4.00 "	63.5	19.8 "	4.45 "	2.69	1692	-	-
4	4.15 "	65.8	28.4 "	5.32 "	3.21	2020	-	-
5	4.25 "	67.4	35.0 "	5.91 "	3.58	2250	-	-
6	4.60 "	73.0	7.0 Hg	2.65 Hg	4.78	3005	-	-
7	5.10 "	80.9	9.8 "	3.13 "	5.65	3550	-	-
8	7.90 "	125.2	11.9 "	3.45 "	6.20	3900	1.0	0.111
9	15.80 "	250.8	26.9 "	5.19 "	9.35	5880	3.0	0.333
10	30.40 "	482.0	44.1 "	6.65 "	12.00	7540	4.0	0.444
11	40.80 "	646.0	51.4 "	7.17 "	12.90	8100	5.0	0.555

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_5

System: Salt-air Particle Size: 20/30 BSS

h_s = 10 cms. h=20 cms. R=2.0 t= 21°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.10 CCl_4	49.2	7.9 CCl_4	2.81 CCl_4	1.70	1070	-	-
2	4.70 "	74.5	21.7 "	4.66 "	2.82	1775	-	-
3	4.80 "	76.1	25.2 "	5.02 "	3.03	1906	-	-
4	4.90 "	77.7	29.3 "	5.41 "	3.28	2064	-	-
5	4.90 "	77.7	32.9 "	5.73 "	3.47	2180	-	-
6	5.10 "	80.9	39.4 "	6.27 "	3.80	2390	-	-
7	6.10 "	96.7	5.5 Hg	2.34 Hg	4.20	2640	-	-
8	6.90 "	109.3	6.1 "	2.47 "	4.43	2785	2.0	0.20
9	8.50 "	134.8	7.5 "	2.74 "	4.90	3080	3.5	0.35
10	17.30 "	274.0	16.4 "	4.05 "	7.30	4590	5.0	0.50
11	23.80 "	377.0	21.5 "	4.64 "	8.34	5240	6.0	0.60
12	35.30 "	559.5	29.5 "	5.43 "	9.77	6150	7.0	0.70
13	50.50 "	800.0	40.5 "	6.36 "	11.46	7200	8.0	0.80

TABLE-3.B_6

System: Salt-air Particle Size: 20/30 BSS

h_s = 10 cms. h=25 cms. R= 2.5 t=22°C

1	2	3	4	5	6	7	8	9
1	1.80 CCl_4	28.6	4.0 CCl_4	2.00 CCl_4	1.20	765	-	-
2	3.40 "	53.9	12.1 "	3.48 "	2.10	1320	-	-
3	4.40 "	69.8	17.2 "	4.14 "	2.50	1572	-	-
4	4.60 "	73.0	22.2 "	4.71 "	2.85	1790	-	-
5	4.80 "	76.1	26.9 "	5.18 "	3.14	1972	-	-
6	4.90 "	77.7	32.7 "	5.72 "	3.47	2180	-	-
7	5.20 "	82.4	5.3 Hg	2.30 Hg	4.13	2600	-	-
8	5.30 "	84.0	6.2 "	2.49 "	4.49	2820	-	-
9	7.10 "	112.5	7.8 "	2.79 "	5.02	3160	1.0	0.10
10	8.70 "	138.0	9.2 "	3.03 "	5.45	3430	3.0	0.30
11	13.00 "	206.0	13.3 "	3.65 "	6.58	4140	4.5	0.45
12	18.40 "	291.5	21.2 "	4.60 "	8.30	5220	5.5	0.55
13	46.00 "	729.0	45.1 "	6.71 "	12.10	7600	7.5	0.75

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT)WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICALES

TABLE-3.B_7

System: Salt-air Particle Size: 20/30 BSS
h_s = 10 cms. h =30 cms. R =3.0 t = 23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.60 CCl_4	41.2	7.3 CCl_4	2.70 CCl_4	1.63	1025	-	-
2	3.30 "	52.3	11.0 C	3.30 "	2.00	1258	-	-
3	4.10 "	65.0	14.9 "	3.86 "	2.33	1466	-	-
4	4.70 "	74.5	18.9 "	4.35 "	2.63	1655	-	-
5	4.80m "	76.1	26.6 "	5.15 "	3.11	1958	-	-
6	5.10 "	80.9	40.8 "	6.39 "	3.88	2440	-	-
7	5.20 "	82.4	6.2 Hg	2.49 Hg	4.49	2820	-	-
8	5.30 "	84.0	8.0 "	2.83 "	5.10	3210	-	-
9	7.10 "	112.5	9.6 "	3.10 "	5.60	3520	1.25	0.125
10	11.10 "	176.0	12.0 "	3.46 "	6.22	3915	3.50	0.350
11	25.40 "	402.5	31.4 "	5.60 "	10.10	6350	4.80	0.480
12	45.00 "	713.0	47.5 "	6.90 "	12.45	7820	6.25	0.625

TABLE-3.B_8

System: Salt-air Particle Size: 20/30 BSS
h_s = 10 cms. h = 35 cms. R = 3.5 t= 24°C

1	2	3	4	5	6	7	8	9
1	2.70 CCl_4	42.8	6.5 CCl_4	2.55 CCl_4	1.50	968	-	-
2	3.90 "	61.8	11.4 "	3.38 "	2.04	1283	-	-
3	4.50 "	71.3	19.5 "	4.42 "	2.67	1680	-	-
4	4.70 "	74.5	23.0 "	4.80 "	2.90	1825	-	-
5	4.85 "	76.8	27.8 "	5.27 "	3.19	2006	-	-
6	4.95 "	78.5	35.5 "	5.95 "	3.60	2265	-	-
7	5.10 "	80.9	47.6 "	6.90 "	4.20	2640	-	-
8	5.30 "	84.0	6.5 Hg	2.55 Hg	4.60	2895	-	-
9	5.50 "	87.1	9.2 "	3.03 "	5.45	3430	-	-
10	11.20 "	172.5	13.9 "	3.73 "	6.72	4230	1.75	0.175
11	14.10 "	223.5	16.2 "	4.02 "	7.24	4550	3.00	0.300
12	25.50 "	404.0	34.3 "	5.85 "	10.53	6630	3.80	0.380
13	37.10 "	587.5	44.0 "	6.63 "	11.92	7500	4.50	0.450

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_9 System: Salt-air Particle Size: 20/30 BSS

h_s = 11 cms. h =22 cms. R =2.0 t =20°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{1/2}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	1.70	CCl_4	26.9	2.4	CCl_4	1.55	CCl_4	0.93	582	-	-
2	2.90	"	46.0	6.0	"	2.45	"	1.48	930	-	-
3	3.90	"	61.8	10.0	"	3.16	"	1.91	1200	-	-
4	5.20	"	82.5	15.2	"	3.90	"	2.35	1478	-	-
5	5.30	"	84.0	21.5	"	4.63	"	2.80	1760	-	-
6	5.50	"	87.2	31.9	"	5.64	"	3.41	2145	-	-
7	5.80	"	92.0	36.6	"	6.05	"	3.67	2308	-	-
8	7.90	"	125.2	5.2	Hg	2.28	Hg	4.10	2580	2.0	0.182
9	11.30	"	179.0	9.4	"	3.06	"	5.52	3472	4.0	0.364
10	11.90	"	188.8	10.5	"	3.24	"	5.80	3650	5.0	0.455
11	15.90	"	252.0	12.5	"	3.54	"	6.37	4005	6.0	0.545
12	28.40	"	450.0	22.8	"	4.78	"	8.60	5410	7.0	0.636
13	38.00	"	602.0	29.0	"	5.39	"	9.70	6100	8.0	0.727

TABLE-3.B_{10} System: Salt-air Particle Size: 20/30 BSS

h_s = 11 cms. h =27.5 cms. R =2.5 t = 21°C

1	2		3	4		5		6	7	8	9
1	2.50	CCl_4	39.6	5.7	CCl_4	2.39	CCl_4	1.43	899	-	-
2	3.80	"	60.2	12.2	"	3.49	"	2.10	1320	-	-
3	5.20	"	82.5	19.6	"	4.43	"	2.67	1680	-	-
4	5.40	"	85.6	23.6	"	4.86	"	2.94	1850	-	-
5	5.60	"	88.8	32.0	"	5.65	"	3.42	2150	-	-
6	5.75	"	91.1	44.2	"	6.65	"	4.04	2540	-	-
7	5.85	"	92.7	6 .1	Hg	2.47	Hg	4.43	2785	0.5	0.046
8	8.10	"	128.3	6.5	"	2.55	"	4.60	2895	1.8	0.164
9	10.80	"	171.2	9.6	"	3.10	"	5.60	3520	3.0	0.273
10	13.70	"	217.2	12.1	"	3.48	"	6.25	3930	4.8	0.436
11	20.50	"	325.0	19.7	"	4.44	"	8.00	5030	5.5	0.500
12	46.90	"	742.0	40.4	"	6.35	"	11.45	7200	7.5	0.681

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{11}

System: Salt-air Particle Size: 20/30 BSS

h_s = 11 cms. h =33 cms. R = 3.0 t =22 °C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.20 CCl_4	34.9	5.4 CCl_4	2.32 CCl_4	1.39	874	-	-
2	3.20 "	50.7	8.9 "	2.98 "	1.80	1132	-	-
3	4.60 "	73.0	15.6 "	3.95 "	2.39	1503	-	-
4	5.70 "	90.4	22.2 "	4.71 "	2.85	1792	-	-
5	5.70 "	90.4	32.3 "	5.68 "	3.44	2162	-	-
6	5.90 "	93.5	5.7 Hg	2.38 Hg	4.30	2705	-	-
7	6.50 "	103.1	7.1 "	2.66 "	4.80	3020	-	-
8	9.00 "	142.8	9.2 "	3.03 "	5.45	3430	2.0	0.182
9	12.50 "	198.2	13.3 "	3.65 "	6.60	4150	3.5	0.318
10	16.30 "	258.2	18.0 "	4.24 "	7.63	4800	4.5	0.409
11	28.20 "	447.0	28.3 "	5.32 "	9.60	6040	6.5	0.591
12	40.30 "	639.0	40.6 "	6.37 "	11.47	7200	7.0	0.636

TABLE-3.B_{12}

System: Salt-air Particle Size: 20/30 BSS

h_s = 11 cms. h =38.5 cms. R =3.5 t = 22°C

1	2	3	4	5	6	7	8	9
1	2.10 CCl_4	33.3	4.4 CCl_4	2.10 CCl_4	1.27	798	-	-
2	3.00 "	47.6	8.7 "	2.95 "	1.78	1120	-	-
3	4.00 "	63.4	12.8 "	3.58 "	2.16	1360	-	-
4	5.40 "	85.6	23.3 "	4.83 "	2.92	1837	-	-
5	5.50 "	87.2	31.4 "	5.60 "	3.40	2140	-	-
6	5.80 "	92.0	45.0 "	6.70 "	4.07	2560	-	-
7	5.90 "	93.5	6.7 Hg	2.59 Hg	4.66	2932	-	-
8	6.60 "	104.7	9.4 "	3.07 "	5.52	3475	-	-
9	9.00 "	142.8	11.0 "	3.32 "	6.00	3770	1.0	0.091
10	13.50 "	214.0	14.1 "	3.76 "	6.76	4250	2.2	0.200
11	17.50 "	277.5	18.6 "	4.31 "	7.77	4890	3.5	0.318
12	23.80 "	377.5	23.7 "	4.87 "	8.76	5510	4.5	0.409
13	47.40 "	751.0	48.5 "	6.96 "	12.54	7890	5.5	0.500

VATIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{13}

System: Salt-air Particle Size: 20/30 BSS

h_s = 12 cms. h = 24 cms. R =2.0 t = 22^{o}C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.30 CCl_4	36.5	3.0 CCl_4	1.73 CCl_4	1.03	647	-	-
2	3.60 "	57.1	6.3 "	2.51 "	1.52	955	-	-
3	4.80 "	76.1	10.7 "	3.27 "	1.98	1245	-	-
4	6.00 "	95.1	16.5 "	4.06 "	2.45	1540	-	-
5	6.10 "	96.7	29.9 "	5.46 "	3.30	2075	-	-
6	6.20 "	98.3	36.0 "	6.00 "	3.63	2280	-	-
7	8.70 "	138.0	4.8 Hg	2.19 Hg	3.95	2485	1.0	0.083
8	10.90 "	172.8	6.2 "	2.49 "	4.50	2830	2.5	0.208
9	13.70 "	217.0	7.5 "	2.74 "	4.92	3095	4.0	0.333
10	16.10 "	255.0	8.9 "	2.98 "	5.35	3360	6.0	0.500
11	21.00 "	332.5	12.3 "	3.51 "	6.32	3980	7.0	0.584
12	40.30 "	639.0	25.3 "	5.03 "	9.06	5700	8.0	0.666

TABLE-3.B_{14}

System: Salt-air Particle Size: 20/30 BSS

h_s = 12 cms. h=30 cms. R =2.5 t = 24^{o}C

1	2	3	4	5	6	7	8	9
1	2.10 CCl_4	33.3	3.6 CCl_4	1.90 CCl_4	1.14	716	-	-
2	3.30 "	52.3	8.5 "	2.92 "	1.76	1107	-	-
3	4.50 "	71.4	13.4 "	3.66 "	2.21	1390	-	-
4	5.70 "	90.4	18.9 "	4.35 "	2.63	1653	-	-
5	6.10 "	96.7	26.0 "	5.10 "	3.09	1942	-	-
6	6.30 "	99.9	37.7 "	6.14 "	3.72	2340	-	-
7	7.10 "	112.7	5.0 Hg	2.23 Hg	4.02	2530	-	-
8	9.10 "	144.1	6.3 "	2.51 "	4.52	2845	1.5	0.125
9	11.40 "	180.8	8.6 "	2.93 "	5.30	3335	3.0	0.250
10	14.10 "	223.5	11.9 "	3.45 "	6.20	3900	4.0	0.333
11	23.60 "	374.0	18.2 "	4.26 "	7.68	4830	6.0	0.500
12	40.80 "	647.0	33.1 "	5.75 "	10.40	6540	7.0	0.584

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{15}

System: Salt-air Particle Size: 20/30 BSS

h_s = 12 cms. h = 36 cms. R = 3.0 t = 25°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{1/2}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	2.50	CCl_4	39.6	4.4	CCl_4	2.10	CCl_4	1.27	798	-	-
2	4.10	"	65.0	9.8	"	3.13	"	1.88	1182	-	-
3	5.60	"	88.8	16.5	"	4.06	"	2.45	1540	-	-
4	6.00	"	95.1	22.7	"	4.76	"	2.88	1810	-	-
5	6.10	"	96.7	33.2	"	5.76	"	3.49	2195	-	-
6	6.20	"	98.3	43.5	"	6.60	"	4.00	2515	-	-
7	6.60	"	104.7	6.6	Hg	2.57	Hg	4.63	2910	-	-
8	9.00	"	142.8	9.0	"	3.00	"	5.40	3400	0.8	0.067
9	12.10	"	192.0	10.6	"	3.26	"	5.87	3685	2.0	0.166
10	16.60	"	263.0	13.8	"	3.72	"	6.70	4210	4.0	0.333
11	18.80	"	298.0	15.3	"	3.91	"	7.02	4415	5.0	0.416
12	36.40	"	577.0	34.4	"	5.86	"	10.55	6640	6.0	0.500

TABLE-3.B_{16}

System: Salt-air Particle Size: 20/30BSS

h_s = 12 cms. h = 42 cms. R = 3.5 t = 25°C

1	2		3	4		5		6	7	8	9
1	2.90	CCl_4	46.0	6.1	CCl_4	2.47	CCl_4	1.48	930	-	-
2	3.50	"	55.5	8.5	"	2.92	"	1.76	1108	-	-
3	5.10	"	80.8	15.2	"	3.90	"	2.35	1480	-	-
4	6.10	"	96.7	24.5	"	4.95	"	3.00	1880	-	-
5	6.20	"	98.3	34.3	"	5.85	"	3.55	2232	-	-
6	6.50	"	103.1	45.0	"	6.70	"	4.06	2555	-	-
7	6.70	"	106.2	8.2	Hg	2.86	Hg	5.15	3240	-	-
8	12.40	"	196.5	12.2	"	3.49	"	6.28	3946	1.0	0.083
9	15.00	"	238.0	14.2	"	3.76	"	6.78	4260	2.0	0.166
10	21.10	"	334.5	17.8	"	4.22	"	7.60	4780	3.0	0.250
11	27.80	"	441.0	23.3	"	4.83	"	8.70	5470	4.5	0.375
12	43.00	"	681.0	35.7	"	5.98	"	10.78	6770	6.0	0.500

RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{17} System: Salt-air Particle Size: 30/40 BSS

h_s = 9 cms. h = 18 cms. R = 2.0 t = 25 °C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{1/2}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	2.30	CCl_4	36.4	3.0	CCl_4	1.73	CCl_4	1.04	655	-	-
2	3.60	"	57.1	6.5	"	2.55	"	1.55	975	-	-
3	4.20	"	66.6	10.2	"	3.19	"	1.94	1220	-	-
4	4.30	"	68.1	13.5	"	3.67	"	2.22	1396	-	-
5	4.40	"	69.7	19.9	"	4.46	"	2.70	1698	-	-
6	4.50	"	71.3	25.8	"	5.08	"	3.07	1930	-	-
7	6.00	"	95.1	32.0	"	5.65	"	3.42	2150	0.5	0.056
8	7.60	"	120.4	37.5	"	6.12	"	3.70	2325	2.0	0.222
9	11.00	"	174.3	49.6	"	7.05	"	4.28	2690	3.5	0.389
10	15.10	"	239.5	8.9	Hg	2.99	Hg	5.39	3390	4.5	0.500
11	24.50	"	388.0	13.3	"	3.64	"	6.60	4150	6.0	0.666
12	43.00	"	681.0	25.7	"	5.07	"	9.13	5740	7.5	0.833

TABLE-3.B_{18} System: Salt-air Particle Size: 30/40 BSS

h_s = 9 cms. h = 22.5 cms. R =2.5 t = 26 °C

1	2		3	4		5		6	7	8	9
1	2.60	CCl_4	41.2	3.6	CCl_4	1.89	CCl_4	1.15	724	-	-
2	3.60	"	57.1	6.7	"	2.58	"	1.56	981	-	-
3	3.80	"	60.2	8.5	"	2.92	"	1.67	1107	-	-
4	4.10	"	65.0	10.6	"	3.26	"	1.97	1240	-	-
5	4.35	"	69.0	17.8	"	4.22	"	2.55	1604	-	-
6	4.55	"	72.1	24.2	"	4.92	"	2.98	1874	-	-
7	4.75	"	75.3	34.3	"	5.85	"	3.55	2232	-	-
8	7.80	"	123.7	49.0	"	7.00	"	4.25	2670	1.5	0.167
9	10.20	"	161.8	8.1	Hg	2.84	Hg	5.12	3220	3.5	0.389
10	16.30	"	258.0	11.8	"	3.44	"	6.20	3900	4.5	0.500
11	25.70	"	407.0	17.4	"	4.17	"	7.50	4715	5.5	0.611
12	31.20	"	495.0	21.1	"	4.60	"	8.30	5215	6.0	0.666
13	48.70	"	772.0	31.0	"	5.56	"	10.02	6310	7.0	0.778

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{19}

System: Salt-air Particle Size: 30/40BSS

h_s = 9 cms. h =27 cms. R=3.0 t =19 °C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.20 CCl_4	50.7	5.8 CCl_4	2.41 CCl_4	1.45	912	-	-
2	3.80 "	60.2	8.1 "	2.84 "	1.71	1075	-	-
3	4.00 "	63.4	12.4 "	3.52 "	2.12	1333	-	-
4	4.15 "	65.8	17.6 "	4.20 "	2.54	1598	-	-
5	4.35 "	69.0	20.9 "	4.57 "	2.76	1735	-	-
6	4.45 "	70.5	28.0 "	5.29 "	3.20	2012	-	-
7	4.45 "	70.5	35.8 "	5.98 "	3.62	2275	-	-
8	5.15 "	81.6	45.5 "	6.75 "	4.10	2580	-	-
9	7.40 "	117.3	6.7 Hg	2.58 "	4.66	2930	1.5	0.167
10	13.50 "	214.0	11.5 "	3.39 "	6.10	3840	4.5	0.500
11	26.80 "	425.0	23.4 "	4.84 "	8.72	5485	5.5	0.611
12	39.80 "	631.0	33.5 "	5.79 "	10.42	6560	6.0	0.666
13	47.80 "	757.0	37.9 "	6.15 "	11.10	6920	7.0	0.778

TABLE-3.B_{20}

System: Salt-air Particle Size: 30/40 BSS

h_s = 9 cms. h = 31.5 cms. R =3.5 t=20°C

1	2	3	4	5	6	7	8	9
1	3.35 CCl_4	53.1	5.8 CCl_4	2.41 CCl_4	1.45	912	-	-
2	3.45 "	54.7	6.7 "	2.58 "	1.56	981	-	-
3	4.00 "	63.4	10.8 "	3.28 "	1.98	1245	-	-
4	4.20 "	66.6	13.6 "	3.68 "	2.22	1397	-	-
5	4.40 "	69.7	18.9 "	4.35 "	2.63	1654	-	-
6	4.40 "	69.7	26.4 "	5.14 "	3.10	1950	-	-
7	4.50 "	71.3	34.6 "	5.89 "	3.57	2245	-	-
8	5.00 "	79.3	51.4 "	7.17 "	4.35	2735	-	-
9	7.50 "	119.0	7.8 Hg	2.79 Hg	5.02	3160	1.0	0.111
10	17.70 "	280.5	17.6 "	4.20 "	7.57	4760	3.5	0.389
11	29.80 "	472.0	28.6 "	5.35 "	9.65	6070	4.5	0.500
12	50.10 "	795.0	41.3 "	6.43 "	11.60	7300	6.0	0.666

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{21}

System: Salt- air   Particle Size: 30/40 BSS

h_s =10 cms.   h = 20 cms.   R =2.0   t=19^oC

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.00 CCl_4	47.5	3.7 CCl_4	1.92 CCl_4	1.15	724	-	-
2	3.40 "	53.9	5.2 "	2.28 "	1.37	862	-	-
3	4.10 "	65.0	7.5 "	2.74 "	1.65	1038	-	-
4	4.55 "	72.1	13.0 "	3.60 "	2.17	1365	-	-
5	4.65 "	73.7	18.8 "	4.34 "	2.62	1650	-	-
6	4.85 "	76.9	23.2 "	4.81 "	2.91	1830	-	-
7	5.35 "	84.8	27.1 "	5.21 "	3.15	1980	-	-
8	6.35 "	100.7	30.1 "	5.49 "	3.32	2087	1.0	0.100
9	8.50 "	134.8	40.2 "	6.34 "	3.84	2415	2.5	0.250
10	10.70 "	169.6	47.2 "	6.87 "	4.17	2620	4.0	0.400
11	15.80 "	250.5	8.6 Hg	2.93 Hg	5.27	3315	5.5	0.550
12	35.00 "	555.0	18.7 "	4.32 "	7.77	4890	7.5	0.750
13	42.30 "	670.0	22.7 "	4.76 "	8.60	5410	8.0	0.800

TABLE-3.B_{22}

System: Salt-air   Particle size: 30/40 BSS

h_s = 10 cms.   h = 25 cms.   R = 2.5   t=20^oC

1	2	3	4	5	6	7	8	9
1	2.60 CCl_4	41.2	3.2 CCl_4	1.79 CCl_4	1.07	673	-	-
2	3.60 "	57.1	5.7 "	2.38 "	1.43	900	-	-
3	4.40 "	69.7	8.2 "	2.86 "	1.73	1088	-	-
4	4.80 "	76.1	19.0 "	4.36 "	2.64	1660	-	-
5	5.00 "	79.3	31.6 "	5.62 "	3.40	2140	-	-
6	6.40 "	101.4	38.7 "	6.22 "	3.77	2370	0.25	0.025
7	7.40 "	117.2	43.5 "	6.60 "	4.00	2515	1.50	0.150
8	9.80 "	155.2	55.1 "	7.43 "	4.51	2840	3.00	0.300
9	11.30 "	179.0	8.6 Hg	2.93 Hg	5.27	3315	4.00	0.400
10	20.80 "	330.0	14.8 "	3.84 "	6.92	4350	5.00	0.500
11	29.10 "	461.0	20.1 "	4.49 "	8.07	5075	6.00	0.600
12	40.70 "	645.0	26.7 "	5.16 "	9.30	5850	7.00	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (...
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System: Salt-air h_s = 10 cms. h= 30 cms. Particle Size: 30/40 BSS R =3.0 t =20°C

Sl. No.	ΔH_1 cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.00	CCl_4	47.5	4.3	CCl_4	2.07	CCl_4	1.25	724	-	-
2	4.00	"	63.4	7.2	"	2.68	"	1.62	1020	-	-
3	4.60	"	72.9	11.3	"	3.36	"	2.02	1270	-	-
4	4.70	"	74.5	15.0	"	3.87	"	2.34	1471	-	-
5	4.95	"	78.5	27.5	"	5.25	"	3.17	1993	-	-
6	5.15	"	81.6	36.0	"	6.00	"	3.63	2282	-	-
7	6.00	"	95.1	46.7	"	6.83	"	4.15	2610	-	-
8	8.00	"	126.8	57.1	"	7.55	"	4.60	2895	1.0	0.100
9	10.30	"	163.2	8.0	Hg	2.83	Hg	5.10	3208	3.0	0.300
10	15.30	"	242.5	12.9	"	3.59	"	6.47	4070	4.0	0.400
11	21.90	"	347.0	17.2	"	4.15	"	7.58	4590	5.0	0.500
12	34.60	"	548.5	27.5	"	5.25	"	9.48	5960	6.0	0.600

TABLE-3.B24

System: Salt-air h_s = 10 cms. h = 35 cms. Particle Size: 30/40 BSS R = 3.5 t=21°C

1	2		3	4		5		6	7	8	9
1	2.70	CCl_4	42.8	3.4	CCl_4	1.84	CCl_4	1.10	692	-	-
2	3.60	"	57.1	6.2	"	2.49	"	1.50	944	-	-
3	4.30	"	68.1	8.3	"	2.88	"	1.74	1094	-	-
4	4.70	"	74.5	13.1	"	3.62	"	2.19	1378	-	-
5	4.80	"	76.1	21.0	"	4.58	"	2.77	1742	-	-
6	4.90	"	77.7	30.1	"	5.49	"	3.32	2088	-	-
7	5.00	"	79.3	36.2	"	6.01	"	3.64	2290	-	-
8	5.30	"	84.0	48.2	"	6.95	"	4.22	2655	-	-
9	8.70	"	138.0	8.2	Hg	2.86	Hg	5.15	3240	1.5	0.150
10	12.80	"	203.0	11.0	"	3.32	"	6.00	3775	3.0	0.300
11	20.40	"	323.0	20.0	"	4.47	"	8.05	5060	4.0	0.400
12	33.50	"	531.0	28.7	"	5.36	"	9.66	6080	5.0	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{25}

System: Salt-air — Particle size: 30/40 BSS

h_s = 11 cms. — h = 22 cms. — R = 2.0 — t = 25^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	3.70	CCl_4	58.6	4.7	CCl_4	2.16	CCl_4	1.30	818	-	-
2	4.20	"	66.5	5.9	"	2.43	"	1.46	919	-	-
3	4.90	"	77.6	7.8	"	2.79	"	1.68	1057	-	-
4	5.15	"	81.6	9.2	"	3.03	"	1.83	1150	-	-
5	5.25	"	83.2	12.1	"	3.48	"	2.10	1320	-	-
6	5.45	"	86.4	16.7	"	4.09	"	2.47	1540	-	-
7	5.55	"	87.9	20.1	"	4.48	"	2.70	1698	-	-
8	7.10	"	112.4	24.3	"	4.93	"	2.98	1875	-	-
9	8.70	"	138.0	30.9	"	5.55	"	3.37	2120	2.0	0.182
10	11.00	"	174.2	39.9	"	6.31	"	3.83	2410	3.0	0.273
11	12.10	"	191.7	44.4	"	6.66	"	4.04	2540	4.5	0.364
12	13.40	"	212.0	6.0	Hg	2.45	Hg	4.40	2768	5.5	0.500
13	16.50	"	261.5	7.3	"	2.70	"	4.87	3060	6.5	0.591
14	21.40	"	339.0	10.4	"	3.22	"	5.80	3650	7.0	0.636
15	30.70	"	486.0	14.7	"	3.83	"	6.90	4340	8.0	0.726

TABLE-3.B_{26}

System: Salt-air — Particle size: 30/40 BSS

h_s = 11 cms. — h= 27.5 cms. — R= 2.5 — t= 26^{o}C

1	2		3	4		5		6	7	8	9
1	3.40	CCl_4	53.9	4.6	CCl_4	2.14	CCl_4	1.29	811	-	-
2	4.70	"	74.5	7.4	"	2.72	"	1.64	1030	-	-
3	5.30	"	84.0	10.9	"	3.30	"	2.00	1258	-	-
4	5.45	"	86.4	16.0	"	4.00	"	2.41	1516	-	-
5	5.55	"	87.9	20.8	"	4.56	"	2.75	1730	-	-
6	5.70	"	90.4	27.5	"	5.25	"	3.17	1993	-	-
7	7.30	"	115.7	33.2	"	5.76	"	3.50	2200	1.0	0.091
8	9.80	"	155.2	43.6	"	6.60	"	4.00	2516	2.5	0.227
9	12.10	"	191.7	5.8	Hg	2.41	Hg	4.33	2725	4.0	0.364
10	18.40	"	291.5	10.1	"	3.18	"	5.74	3610	5.5	0.500
11	38.00	"	602.0	21.4	"	4.62	"	8.33	5240	7.5	0.681

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{27}

System: Salt-air Particle Size: 30/40 BSS

h_s = 11 cms. h =33.0 cms. R=3.0 t =25^{o} C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
	2	3	4	5	6	7	8	9
	3.0 CCl_4	47.5	3.1 CCl_4	1.76 CCl_4	1.06	660	-	-
	4.0 "	63.4	5.1 "	2.26 "	1.36	855	-	-
3	5.00 "	79.3	7.8 "	2.79 "	1.73	1088	-	-
4	5.20 "	82.4	10.7 "	3.27 "	1.97	1240	-	-
5	5.30 "	84.0	16.8 "	4.10 "	2.48	1560	-	-
6	5.40 "	85.5	22.4 "	4.73 "	2.85	1792	-	-
7	5.60 "	88.7	28.6 "	5.35 "	3.25	2045	-	-
8	7.20 "	114.0	43.9 "	6.62 "	4.01	2520	-	-
9	8.90 "	141.0	53.0 "	7.27 "	4.42	2780	0.5	0.045
10	12.50 "	198.0	8.5 Hg	2.92 Hg	5.25	3300	1.5	0.136
11	17.00 "	269.0	11.9 "	3.45 "	6.22	3915	4.0	0.364
12	30.20 "	479.0	20.5 "	4.53 "	8.15	5120	5.0	0.455

TABLE-3.B_{28}

System: Salt-air Particle size: 30/40 BSS

h_s = 11 cms. h =38.5 cms. R=3.5 t=25^{o}C

1	2	3	4	5	6	7	8	9
1	3.50 CCl_4	55.5	4.1 CCl_4	2.02 CCl_4	1.22	768	-	-
2	4.70 "	74.5	7.2 "	2.68 "	1.61	1012	-	-
3	5.30 "	84.0	10.9 "	3.30 "	2.20	1383	-	-
4	5.40 "	85.5	14.6 "	3.82 "	2.30	1447	-	-
5	5.50 "	87.2	22.3 "	4.72 "	2.85	1792	-	-
6	5.60 "	88.7	32.0 "	5.56 "	3.42	2150	-	-
7	5.60 "	88.7	45.0 "	6.70 "	4.06	2555	-	-
8	8.30 "	131.5	6.7 Hg	2.58 Hg	4.66	2930	1.0	0.091
9	15.30 "	242.5	10.7 "	3.27 "	5.90	3710	4.0	0.364
10	22.90 "	347.0	18.0 "	4.24 "	7.63	4800	5.5	0.500
11	32.00 "	507.0	22.1 "	4.70 "	8.50	5350	6.5	0.591

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{29}

System: Salt-air Particle size: 30/40 BSS

h_s = 12 cms. h=24 cms. R=2.0 t=25 °C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.5 CCl_4	55.5	3.1 CCl_4	1.76 CCl_4	1.05	661	-	-
2	4.70 "	74.5	5.5 "	2.34 "	1.40	880	-	--
3	5.50 "	87.2	7.6 "	2.76 "	1.66	1044	-	-
4	5.60 "	88.7	9.3 "	3.05 "	1.85	1163	-	-
5	5.90 "	93.5	15.4 "	3.92 "	2.37	1490	-	-
6	6.00 "	95.1	20.1 "	4.49 "	2.70	1700	-	-
7	8.30 "	131.5	26.4 "	5.14 "	3.10	1950	1.5	0.125
8	10.10 "	160.0	31.5 "	5.61 "	3.40	2140	3.0	0.250
9	12.20 "	193.2	37.1 "	6.10 "	3.70	2325	4.0	0.333
10	14.50 "	230.0	5.9 Hg	2.43 Hg	4.38	2755	6.0	0.500
11	26.30 "	417.0	11.6 "	3.40 "	6.15	3870	7.5	0.625
12	42.60 "	675.0	19.1 "	4.37 "	7.88	4950	9.0	0.750

TABLE-3.B_{30}

System: Salt-air Particle size: 30/40 BSS

h_s =12 cms h= 30 cms R=2.5 t =18°C

1	2	3	4	5	6	7	8	9
1	3.50 CCl_4	55.5	3.8 CCl_4	1.95 CCl_4	1.17	736	-	-
2	4.50 "	71.3	6.3 "	2.51 "	1.51	950	-	-
3	5.50 "	87.2	8.6 "	2.93 "	1.76	1107	-	-
4	5.70 "	90.4	11.1 "	3.33 "	2.00	1258	-	-
5	5.90 "	93.5	15.4 "	3.92 "	2.37	1490	-	-
6	6.10 "	96.7	23.1 "	4.80 "	2.90	1824	-	-
7	6.90 "	109.3	31.6 "	5.62 "	3.40	2140	-	-
8	9.40 "	149.0	35.8 "	5.98 "	3.62	2275	1.8	0.150
9	10.30 "	163.2	5.2 Hg	2.28 Hg	4.10	2580	3.0	0.250
10	13.30 "	210.6	7.0 "	2.64 "	4.75	2985	4.5	0.375
11	19.20 "	304.0	10.4 "	3.22 "	5.80	3645	6.0	0.500
12	36.40 "	577.0	20.5 "	4.53 "	8.16	5135	7.5	0.625
13	42.70 "	676.0	23.8 "	4.88 "	8.80	5530	8.0	0.666

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{31} System: Salt-air Particle size: 30/40 BSS

h_s = 12 cms. h=36 cms. R=3.0 t=19 ^{o}C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.90 CCl_4	61.8	4.9 CCl_4	2.21 CCl_4	1.33	836	-	-
2	4.50 "	71.3	6.4 "	2.53 "	1.52	956	-	-
3	5.70 "	90.4	10.7 "	3.27 "	1.97	1240	-	-
4	5.80 "	92.0	15.5 "	3.94 "	2.38	1497	-	-
5	6.00 "	95.1	25.0 "	5.00 "	3.02	1900	-	-
6	6.20 "	98.3	36.7 "	6.05 "	3.67	2308	-	-
7	8.50 "	134.7	40.4 "	6.35 "	3.85	2420	1.2	0.100
8	10.90 "	172.8	6.1 Hg	2.47 Hg	4.45	2800	2.4	0.200
9	13.50 "	214.0	7.9 "	2.81 "	5.07	3190	3.0	0.250
10	17.00 "	269.5	8.9 "	2.98 "	5.35	3365	4.0	0.333
11	19.40 "	307.5	10.5 "	3.24 "	5.82	3660	5.0	0.416
12	40.60 "	644.0	22.6 "	4.73 "	8.52	5360	7.5	0.625

TABLE-3.B_{32} System: Salt-air Particle size: 30/40 BSS

h_s = 12 cms. h = 42 cms R =3.5 t =20 ^{o}C

1	2	3	4	5	6	7	8	9
1	2.90 CCl_4	46.0	4.1 CCl_4	2.02 CCl_4	1.21	761	-	-
2	5.60 "	88.7	10.5 "	3.24 "	1.95	1226	-	-
3	5.70 "	90.4	11.7 "	3.42 "	2.06	1296	-	-
4	5.80 "	92.0	14.4 "	3.80 "	2.30	1448	-	-
5	6.00 "	95.1	19.4 "	4.40 "	2.65	1667	-	-
6	6.10 "	96.7	26.2 "	5.12 "	3.09	1943	-	-
7	6.30 "	99.9	36.8 "	6.06 "	3.68	2315	-	-
8	7.90 "	125.1	53.4 "	7.30 "	4.44	2792	-	-
9	8.90 "	141.0	7.1 Hg	2.66 Hg	4.80	3020	1.2	0.100
10	12.80 "	203.0	8.8 "	2.96 "	5.33	3355	3.0	0.250
11	16.90 "	268.0	10.8 "	3.28 "	5.90	3710	4.5	0.375
12	20.60 "	326.5	14.3 "	3.78 "	6.82	4290	5.0	0.416
13	43.30 "	686.0	30.6 "	5.54 "	10.00	6290	7.2	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{33}

System: Salt-air   Particle size: 40/52 BSS
h_s = 9 cms.   h= 18 cms.   R=2.0   t= 20°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.60 CCl_4	41.2	1.5 CCl_4	1.23 CCl_4	0.73	459	-	-
2	4.40 "	69.7	4.4 "	2.10 "	1.26	786	-	-
3	4.70 "	74.5	5.2 "	2.28 "	1.37	861	-	-
4	4.80 "	76.0	7.0 "	2.64 "	1.60	1007	-	-
5	4.90 "	77.6	9.9 "	3.15 "	1.90	1195	-	-
6	5.00 "	79.2	16.0 "	4.00 "	2.41	1517	-	-
7	5.00 "	79.2	17.9 "	4.24 "	2.55	1603	-	-
8	6.40 "	101.5	22.8 "	4.78 "	2.89	1818	-	-
9	8.30 "	131.5	27.4 "	5.24 "	3.16	1988	1.0	0.111
10	13.10 "	207.5	41.4 "	6.44 "	3.90	2450	3.0	0.333
11	23.10 "	366.0	7.8 Hg	2.79 Hg	5.02	3160	5.0	0.555
12	34.50 "	546.0	11.2 "	3.35 "	6.00	3770	6.0	0.666
13	53.40 "	846.0	18.0 "	4.25 "	7.65	4810	7.2	0.800

TABLE-3.B_{34}

System: Salt-air   Particle size: 40/52 BSS
h_s = 9 cms.   h=22.5 cms.   R =2.5   t=21°C

1	2	3	4	5	6	7	8	9
1	3.00 CCl_4	47.5	2.1 CCl_4	1.45 CCl_4	0.85	535	-	-
2	4.40 "	69.7	4.1 "	2.03 "	1.22	768	-	-
3	4.60 "	72.9	6.6 "	2.57 "	1.55	975	-	-
4	4.90 "	77.6	15.7 "	3.96 "	2.40	1510	-	-
5	5.00 "	79.2	21.8 "	4.67 "	2.83	1780	-	-
6	5.00 "	79.2	24.7 "	4.97 "	3.00	1887	-	-
7	7.70 "	122.0	29.2 "	5.41 "	3.27	2055	0.9	0.100
8	9.80 "	155.2	37.6 "	6.14 "	3.72	2340	1.8	0.200
9	13.50 "	214.0	49.1 "	7.00 "	4.25	2675	3.0	0.333
10	16.50 "	261.5	8.0 Hg	2.83 Hg	5.10	3205	3.6	0.400
11	19.10 "	302.5	8.5 "	2.92 "	5.24	3295	4.5	0.500
12	26.70 "	423.0	11.6 "	3.41 "	6.13	3855	5.4	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{35}

System: Salt-air   Particle size: 40/52 BSS
h_s = 9 cms.   h =27 cms.   R=3.0   t= 23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.50 CCl_4	55.5	2.4 CCl_4	1.55 CCl_4	0.93	585	-	-
2	4.70 "	74.5	5.9 "	2.43 "	1.46	919	-	-
3	4.80 "	76.0	8.4 "	2.90 "	1.75	1100	-	-
4	4.90 "	77.6	12.8 "	3.58 "	2.16	1360	-	-
5	5.00 "	79.2	21.0 "	4.58 "	2.77	1742	-	-
6	5.10 "	80.8	30.8 "	5.55 "	3.36	2112	-	-
7	8.00 "	127.0	39.2 "	6.26 "	3.80	2390	-	-
8	10.60 "	168.0	51.4 "	7.17 "	4.35	2735	1.5	0.167
9	14.90 "	236.0	7.0 Hg	2.64 Hg	4.75	2990	2.7	0.300
10	26.20 "	415.0	13.6 "	3.69 "	6.63	4170	4.0	0.444
11	42.80 "	679.0	21.2 "	4.61 "	8.30	5215	5.4	0.600
12	6.20 Hg	844.0	25.4 "	5.04 "	9.06	5700	6.0	0.666
13	9.80 "	1332.0	37.6 "	6.14 "	11.04	6940	7.2	0.800

TABLE 3.B_{36}

System: Salt-air   Particle size: 40/52 BSS
h_s = 9 cms.   h = 31.5 cms.   R =3.5   t=24°C

1	2	3	4	5	6	7	8	9
1	2.80 CCl_4	44.4	1.8 CCl_4	1.34 CCl_4	0.80	503	-	-
2	4.20 "	66.5	4.0 "	2.00 "	1.20	755	-	-
3	4.70 "	74.5	6.0 "	2.45 "	1.48	930	-	-
4	4.80 "	76.0	11.9 "	3.45 "	2.08	1308	-	-
5	5.00 "	79.2	27.1 "	5.21 "	3.15	1980	-	-
6	5.10 "	80.8	38.4 "	6.20 "	3.75	2360	-	-
7	7.40 "	117.2	48.6 "	6.99 "	4.24	2665	-	-
8	11.20 "	177.5	6.5 Hg	2.55 Hg	4.60	2892	1.8	0.200
9	18.00 "	285.0	11.4 "	3.38 "	6.06	3815	2.7	0.300
10	28.20 "	447.0	15.6 "	3.95 "	7.10	4460	3.6	0.400
11	35.10 "	556.0	17.4 "	4.17 "	7.50	4710	4.5	0.500
12	9.50 Hg	1292.0	38.8 "	6.26 "	11.27	7080	7.0	0.780

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B37

System: Salt-air — h_s = 10 cms. — h=20 cms. — Particle size: 40/52 BSS — R=2.0 — $t=25^{\circ}C$

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.70	CCl_4	58.6	1.9	CCl_4	1.38	CCl_4	0.82	515	-	-
2	5.35	"	84.8	4.0	"	2.00	"	1.20	755	-	-
3	5.45	"	86.4	4.4	"	2.10	"	1.26	792	-	-
4	5.45	"	86.4	6.1	"	2.46	"	1.48	930	-	-
5	5.55	"	88.0	9.4	"	3.07	"	1.85	1162	-	-
6	5.65	"	89.5	13.9	"	3.73	"	2.25	1415	-	-
7	7.80	"	123.5	18.9	"	4.35	"	2.63	1654	0.8	0.08
8	10.50	"	163.3	27.2	"	5.22	"	3.15	1980	2.5	0.25
9	14.70	"	233.0	35.0	"	5.91	"	3.58	2250	4.0	0.40
10	21.90	"	347.0	53.2	"	7.31	"	4.45	2795	5.5	0.55
11	30.20	"	479.0	8.8	Hg	2.97	Hg	5.34	3360	7.0	0.70
12	45.50	"	721.0	12.7	"	3.57	"	6.43	4050	8.0	0.80

TABLE-3.B38

System: Salt-air — h_s = 10 cms. — h=25 cms. — Particle size: 40/52 BSS — R =2.5 — $t =23^{\circ}C$

1	2		3	4		5		6	7	8	9
1	3.00	CCl_4	47.6	1.4	CCl_4	1.18	CCl_4	0.70	440	-	-
2	4.20	"	66.6	3.0	"	1.73	"	1.03	648	-	-
3	5.10	"	80.8	4.4	"	2.10	"	1.26	792	-	-
4	5.20	"	82.4	5.5	"	2.35	"	1.41	886	-	-
5	5.30	"	84.0	8.8	"	2.97	"	1.79	1126	-	-
6	5.70	"	90.4	16.4	"	4.05	"	2.45	1540	-	-
7	7.10	"	112.5	25.3	"	5.03	"	3.04	1911	-	-
8	9.90	"	157.0	31.6	"	5.62	"	3.40	2140	1.20	0.120
9	11.30	"	179.0	36.6	"	6.05	"	3.67	2306	2.00	0.200
10	19.10	"	302.5	54.1	"	7.36	"	4.47	2815	4.00	0.400
11	25.10	"	398.0	10.0	Hg	3.16	Hg	5.70	3585	5.00	0.500
12	36.50	"	578.0	13.6	"	3.69	"	6.63	4170	6.00	0.600
13	7.00	Hg	952.0	22.5	"	4.75	"	8.56	5390	7.75	0.775

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{39}

System: Salt-air   Particle size: 40/52 BSS
h_s = 10 cms.   h= 30 cms.   R=3.0   t = 24^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{1/2}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.50	CCl_4	55.5	1.9	CCl_4	1.38	CCl_4	0.82	515	-	-
2	4.60	"	72.9	3.4	"	1.82	"	1.09	686	-	-
3	5.20	"	82.4	5.4	"	2.32	"	1.39	875	-	-
4	5.40	"	86.6	11.4	"	3.38	"	2.04	1282	-	-
5	5.60	"	88.8	20.4	"	4.52	"	2.73	1718	-	-
6	5.70	"	90.4	27.5	"	5.25	"	3.17	1992	-	-
7	10.20	"	161.6	34.4	"	5.86	"	3.55	2132	1.00	0.100
9	15.40	"	244.0	53.3	"	7.31	"	4.45	2800	2.75	0.275
10	20.90	"	332.0	10.1	Hg	3.18	Hg	5.71	3590	4.50	0.450
11	30.50	"	483.5	15.1	"	3.89	"	7.00	4400	5.50	0.550
12	7.00	Hg	952.0	27.3	"	5.22	"	9.40	5910	7.50	0.750

TABLE-3.B_{40}

System : Salt-air   Particle size: 40/52 BSS
h_s = 10 cms.   h = 35 cms.   R =3.5   t= 24^{o}C

1	2		3	4		5		6	7	8	9
1	2.70	CCl_4	42.8	1.3	CCl_4	1.14	CCl_4	0.68	428	-	-
2	3.90	"	61.8	2.7	"	1.65	"	0.99	622	-	-
3	5.50	"	87.2	5.1	"	2.26	"	1.36	855	-	-
4	5.60	"	88.8	10.0	"	3.16	"	1.91	1200	-	-
5	5.80	"	92.0	22.8	"	4.77	"	2.88	1810	-	-
6	5.90	"	93.5	30.2	"	5.50	"	3.33	2092	-	-
7	6.90	"	109.3	37.8	"	6.15	"	3.73	2345	-	-
8	12.10	"	192.0	55.5	"	7.45	"	4.52	2840	1.5	0.150
9	14.10	"	223.5	7.5	Hg	2.74	Hg	4.91	3086	2.5	0.250
10	22.10	"	350.5	12.0	"	3.46	"	6.22	3915	4.0	0.400
11	43.20	"	685.0	23.1	"	4.81	"	8.67	5450	5.5	0.550
12	7.60	Hg	1033.0	30.5	"	5.53	"	9.96	6265	7.0	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{41}

System: Salt-air Particle size: 40/52 BSS
h_s =11 cms. h = 22 cms. R = 2.0 t = 19 ^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	2.80	CCl_4	44.4	1.0	CCl_4	1.0	CCl_4	0.60	377	-	-
2	5.70	"	90.4	3.7	"	1.93	"	1.15	724	-	-
3	5.80	"	92.0	4.8	"	2.19	"	1.32	830	-	-
4	5.90	"	93.5	7.2	"	2.68	"	1.62	1019	-	-
5	6.10	"	96.6	15.1	"	3.89	"	2.35	1480	-	-
6	8.10	"	128.3	18.9	"	4.35	"	2.63	1655	-	-
7	9.50	"	150.4	22.9	"	4.79	"	2.90	1825	1.1	0.100
8	12.10	"	192.0	26.0	"	5.10	"	3.09	1944	2.2	0.200
9	15.00	"	237.5	32.1	"	5.67	"	3.43	2160	3.3	0.300
10	19.20	"	304.0	40.8	"	6.39	"	3.88	2440	5.0	0.455
11	28.00	"	444.0	59.5	"	7.70	"	4.69	2950	6.6	0.600
12	3.40	Hg	462.0	8.1	Hg	2.84	Hg	5.13	3225	7.0	0.636
13	6.00	"	816.0	15.2	"	3.90	"	7.00	4400	8.8	0.800

TABLE-3.B_{42}

System: Salt-air Particle size: 40/52 BSS
h_s = 11 cms. h=27.5 cms. R =2.5 t=20 ^{o}C

1	2		3	4		5		6	7	8	9
1	2.40	CCl_4	38.0	0.8	CCl_4	0.90	CCl_4	0.53	333	-	-
2	4.30	"	68.1	2.6	"	1.61	"	0.96	604	-	-
3	5.80	"	92.0	4.6	"	2.14	"	1.30	818	-	-
4	5.80	"	92.0	6.3	"	2.51	"	1.51	950	-	-
5	5.90	"	93.5	10.2	"	3.20	"	1.93	1212	-	-
6	6.10	"	96.6	15.3	"	3.92	"	2.36	1484	-	-
7	7.90	"	125.0	25.1	"	5.01	"	3.03	1906	-	-
8	10.10	"	160.0	28.4	"	5.33	"	3.22	2025	1.1	0.100
9	17.00	"	269.5	44.0	"	6.64	"	4.02	2530	3.3	0.300
10	2.60	Hg	353.5	6.4	Hg	2.53	"	4.55	2860	4.4	0.400
11	3.20	"	435.0	9.5	"	3.08	"	5.54	3480	5.5	0.500
12	6.80	"	925.0	19.8	"	4.45	"	8.00	5030	7.7	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{43}

System: Salt-air Particle size: 40/52 BSS

h_s = 11 cms. h =33.0 cms. R =3.0 t=21 ^oC

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.40 CCl_4	38.0	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	4.00 "	63.4	2.2 "	1.48 "	0.89	560	-	-
3	5.00 "	79.3	3.6 "	1.90 "	1.14	717	-	-
4	5.90 "	93.5	4.9 "	2.27 "	1.33	836	-	-
5	6.00 "	95.0	9.6 "	3.10 "	1.87	1175	-	-
6	6.10 "	96.6	16.6 "	4.07 "	2.45	1540	-	-
7	6.20 "	98.2	28.1 "	5.30 "	3.20	2010	-	-
8	11.30 "	179.0	38.1 "	6.17 "	3.74	2350	1.5	0.136
9	15.50 "	246.0	49.7 "	7.05 "	4.27	2685	2.5	0.227
10	3.90 Hg	530.0	13.1 "	3.62 "	6.50	4090	5.5	0.500
11	5.75 "	782.0	20.2 "	4.50 "	8.10	5090	6.0	0.545
12	9.55 "	1300.0	32.6 "	5.71 "	10.30	6480	8.0	0.727

TABLE-3.B_{44}

System: Salt-air Particle size: 40/52

h_s =11 cms. h=38.5 cms. R= 3.5 t= 21 ^oC

1	2	3	4	5	6	7	8	9
1	3.70 CCl_4	58.6	1.8 CCl_4	1.34 CCl_4	0.80	503	-	-
2	4.70 "	74.5	3.0 "	1.73 "	1.03	648	-	-
3	6.10 "	96.6	5.1 "	2.26 "	1.36	855	-	-
4	6.20 "	98.2	10.0 "	3.16 "	1.91	1200	-	-
5	6.30 "	99.8	19.2 "	4.39 "	2.65	1668	-	-
6	6.50 "	103.0	28.6 "	5.53 "	3.24	2040	-	-
7	6.60 "	104.6	33.9 "	5.82 "	3.52	2212	-	-
8	9.70 "	153.8	46.0 "	6.79 "	4.11	2585	-	-
9	1.80 Hg	244.8	7.4 Hg	2.72 Hg	4.90	3080	2.2	0.20
10	2.40 "	326.0	9.6 "	3.10 "	5.60	3520	4.0	0.364
11	5.60 "	761.0	24.4 "	4.94 "	8.90	5600	5.5	0.500
12	8.10 "	1102.0	33.3 "	5.77 "	10.40	6550	6.5	0.590

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{45}

System: Salt-air Particle size: 40/52 BSS
h_s = 12 cms. h= 24 cms. R =2.0 t =23^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		H Kg/hr	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	4.30	CCl_4	68.2	1.4	CCl_4	1.18	CCl_4	0.70	4.40	-	-
2	5.90	"	93.5	2.5	"	1.58	"	0.95	597	-	-
3	6.30	"	99.8	4.8	"	2.19	"	1.32	830	-	-
4	6.50	"	103.0	8.3	"	2.88	"	1.74	1094	-	-
5	6.60	"	104.6	13.7	"	3.70	"	2.23	1402	-	-
6	9.70	"	153.8	19.2	"	4.38	"	2.65	1668	1.0	0.083
7	11.60	"	184.0	23.3	"	4.83	"	2.92	1837	2.0	0.167
8	15.90	"	252.0	30.1	"	5.50	"	3.33	2095	4.0	0.333
9	20.80	"	330.0	40.2	"	6.35	"	3.85	2420	5.0	0.417
10	23.60	"	374.0	47.8	"	6.91	"	4.20	2640	6.0	0.500
11	3.40	Hg	462.0	6.7	Hg	2.59	Hg	4.68	2945	8.0	0.666
12	6.60	"	897.0	15.0	"	3.87	"	6.95	4370	9.6	0.800

TABLE-3.B_{46}

System: Salt-air Particle size: 40/52 BSS
h_s = 12 cms. h= 30 cms. R = 2.5 t =23^{o}C

1	2		3	4		5		6	7	8	9
1	2.60	CCl_4	41.2	1.0	CCl_4	1.00	CCl_4	0.60	377	-	-
2	3.90	"	61.8	2.0	"	1.42	"	0.85	535	-	-
3	5.40	"	85.6	3.6	"	1.90	"	1.14	717	-	-
4	6.40	"	101.4	6.6	"	2.57	"	1.55	975	-	-
5	6.60	"	104.6	10.5	"	3.24	"	1.95	1226	-	-
6	6.70	"	106.2	15.2	"	3.90	"	2.35	1480	-	-
7	7.70	"	122.0	23.1	"	4.81	"	2.90	1822	-	-
8	10.90	"	173.0	28.4	"	5.33	"	3.22	2025	1.5	0.125
9	15.00	"	237.5	37.9	"	6.15	"	3.73	2345	3.0	0.250
10	19.20	"	304.0	47.8	"	6.91	"	4.20	2640	4.0	0.333
11	3.10	Hg	421.0	7.5	Hg	2.74	Hg	4.91	3090	5.0	0.417
12	4.40	"	598.0	10.8	"	3.29	"	5.90	3710	6.0	0.500
13	8.40	"	1142.0	22.4	"	4.73	"	8.50	5350	9.0	0.750

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{47}

System: Salt-air Particle size: 40/52 BSS
h_s = 12 cms. h =36.0 cms. R = 3.0 t = 24°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.30 CCl_4	52.3	1.5 CCl_4	1.22 CCl_4	0.73	459	-	-
2	4.50 "	71.4	2.6 "	1.62 "	0.94	591	-	-
3	6.10 "	96.6	4.8 "	2.19 "	1.32	830	-	-
4	6.40 "	101.4	7.0 "	2.65 "	1.60	1006	-	-
5	6.60 "	104.6	13.9 "	3.73 "	2.25	1415	-	-
6	6.70 "	106.2	19.9 "	4.46 "	2.70	1700	-	-
7	6.80 "	107.8	29.0 "	5.39 "	3.25	2045	-	-
8	10.40 "	165.0	33.9 "	5.82 "	3.52	2210	1.2	0.100
9	14.20 "	225.0	41.4 "	6.44 "	3.90	2450	2.0	0.167
10	2.30 Hg	312.5	6.3 Hg	2.51 Hg	4.52	2840	4.0	0.333
11	4.90 "	666.0	15.6 "	3.95 "	7.10	4460	6.0	0.500
12	6.75 "	917.0	21.0 "	4.58 "	8.25	5190	7.2	0.600

TABLE-3.B_{48}

System: Salt-air Particle size: 40/52 BSS
h_s = 12 cms. h= 42 cms. R =3.5 t=24°C

1	2	3	4	5	6	7	8	9
1	2.50 CCl_4	39.6	0.8 CCl_4	0.90 CCl_4	0.53	333	-	-
2	3.50 "	55.5	1.4 "	1.18 "	0.70	440	-	-
3	5.10 "	80.9	2.8 "	1.67 "	1.00	629	-	-
4	6.60 "	104.6	4.6 "	2.14 "	1.30	818	-	-
5	6.70 "	106.2	12.7 "	3.57 "	2.15	1352	-	-
6	6.80 "	107.8	25.6 "	5.06 "	3.06	1925	-	-
7	6.90 "	109.4	38.7 "	6.22 "	3.77	2372	-	-
8	10.40 "	165.0	45.3 "	6.73 "	4.07	2560	-	-
9	1.50 Hg	204.0	6.2 Hg	2.49 Hg	4.50	2830	2.0	0.167
10	2.30 "	312.5	9.3 "	3.05 "	5.50	3460	3.0	0.250
11	3.20 "	435.0	12.0 "	3.46 "	6.21	3906	4.8	0.400
12	6.00 "	816.0	20.9 "	4.57 "	8.22	5170	6.0	0.500
13	7.60 "	1033.0	28.2 "	5.31 "	9.60	6040	7.2	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{49}

System: Salt-air h_s = 9 cms. h =18 cms. Particle size: 52/60 BSS R =2.0 t= 21°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.30 CCl_4	36.5	0.7 CCl_4	0.83 CCl_4	0.50	314	-	-
2	3.90 "	61.8	1.6 "	1.26 "	0.75	472	-	-
3	4.90 "	77.6	2.6 "	1.60 "	0.96	604	-	-
4	5.10 "	80.8	5.0 "	2.24 "	1.34	843	-	-
5	5.20 "	82.4	8.3 "	2.88 "	1.74	1094	-	-
6	5.30 "	84.0	11.2 "	3.34 "	2.01	1264	-	-
7	6.90 "	109.3	16.1 "	4.01 "	2.42	1522	-	-
8	10.50 "	166.5	19.6 "	4.40 "	2.65	1668	1.5	0.166
9	14.10 "	223.5	24.1 "	4.91 "	2.97	1870	3.0	0.333
10	21.90 "	347.5	35.5 "	5.95 "	3.60	2265	4.0	0.445
11	30.60 "	485.0	45.5 "	6.75 "	4.10	2580	5.4	0.600
12	42.20 "	670.0	62.5 "	7.90 "	4.80	3020	6.3	0.700

TABLE-3.B_{50}

System: Salt-air h_s = 9 cms. h= 22.5 cms. Particle size: 52/60 BSS R = 2.5 t = 24°C

1	2	3	4	5	6	7	8	9
1	2.80 CCl_4	44.4	0.6 CCl_4	0.78 CCl_4	0.45	283	-	-
2	4.70 "	74.5	1.6 "	1.26 "	0.75	472	-	-
3	4.90 "	77.6	2.6 "	1.61 "	0.96	604	-	-
4	5.00 "	79.2	4.0 "	2.00 "	1.20	755	-	-
5	5.10 "	80.8	6.2 "	2.49 "	1.50	944	-	-
6	5.20 "	82.4	12.1 "	3.48 "	2.10	1320	-	-
7	5.30 "	84.0	20.3 "	4.50 "	2.71	1705	-	-
8	8.10 "	128.3	23.4 "	4.84 "	2.92	1838	-	-
9	11.50 "	182.2	30.0 "	5.47 "	3.31	2080	1.0	0.111
10	18.90 "	299.5	38.7 "	6.22 "	3.77	2370	2.7	0.300
11	24.10 "	382.0	50.8 "	7.11 "	4.31	2715	3.6	0.400
12	3.80 Hg	517.0	8.1 Hg	2.84 Hg	5.13	3225	5.0	0.556
13	6.80 "	925.0	15.1 "	3.88 "	7.00	4400	6.3	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{51}

System: Salt-air   Particle size: 52/60 BSS
h_s = 9 cms.   h=27.0 cms   R= 3.0   t= 25°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.40 CCl_4	53.9	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	4.20 "	66.6	1.4 "	1.18 "	0.70	440	-	-
3	5.00 "	79.2	2.4 "	1.55 "	0.93	585	-	-
4	5.00 "	79.2	3.2 "	1.79 "	1.07	673	-	-
5	5.10 "	80.8	5.0 "	2.24 "	1.34	843	-	-
6	5.20 "	82.4	7.3 "	2.70 "	1.63	1025	-	-
7	5.40 "	85.6	12.4 "	3.52 "	2.12	1333	-	-
8	5.60 "	88.8	23.5 "	4.85 "	2.93	1842	-	-
9	8.10 "	128.3	29.1 "	5.40 "	3.26	2050	-	-
10	11.90 "	188.8	41.5 "	6.45 "	3.91	2460	1.0	0.111
11	16.90 "	268.0	44.8 "	6.70 "	4.06	2555	2.0	0.222
12	3.00 Hg	408.0	8.9 Hg	2.98 Hg	5.35	3365	4.0	0.445
13	6.10 "	830.0	16.7 "	4.09 "	7.38	4645	5.4	0.600

TABLE-3.B_{52}

System: Salt-air   Particle size: 52/60 BSS
h_s = 9 cms.   h =31.5 cms.   R =3.5   t = 25°C

1	2	3	4	5	6	7	8	9
1	3.70 CCl_4	58.6	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	5.00 "	79.2	1.8 "	1.34 "	0.81	510	-	-
3	5.00 "	79.2	3.2 "	1.79 "	1.07	673	-	-
4	5.10 "	80.8	6.2 "	2.49 "	1.50	944	-	-
5	5.20 "	82.4	11.7 "	3.42 "	2.06	1297	-	-
6	5.40 "	85.6	18.0 "	4.24 "	2.56	1610	-	-
7	7.30 "	115.7	36.4 "	6.04 "	3.66	2300	-	-
8	1.50 Hg	204.0	5.6 Hg	2.36 Hg	4.28	2693	1.0	0.111
9	3.20 "	435.0	9.9 "	3.15 "	5.66	3560	2.7	0.300
10	5.00 "	680.0	14.4 "	3.80 "	6.83	4300	3.6	0.400
11	7.60 "	1033.0	21.0 "	4.58 "	8.26	5200	4.5	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{53}

System: Salt- air   Particle size: 52/60 BSS

h_s = 10 cms.   h = 20 cms.   R=2.0   t=20 °C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{1/2}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.30	CCl_4	52.3	0.6	CCl_4	0.78	CCl_4	0.45	283	-	-
2	4.30	"	68.2	1.3	"	1.14	"	0.67	421	-	-
3	5.50	"	87.2	2.5	"	1.58	"	0.94	591	-	-
4	5.70	"	90.4	4.1	"	2.02	"	1.21	761	-	-
5	6.00	"	95.1	7.4	"	2.72	"	1.64	1031	-	-
6	6.10	"	96.7	11.7	"	3.42	"	2.06	1297	-	-
7	8.50	"	134.8	15.5	"	3.94	"	2.37	1490	0.50	0.050
8	12.50	"	198.0	20.5	"	4.52	"	2.73	1720	1.75	0.175
9	17.30	"	274.0	26.4	"	5.14	"	3.10	1950	3.00	0.300
10	30.10	"	477.0	42.0	"	6.48	"	3.92	2465	5.00	0.500
11	43.10	"	684.0	58.3	"	7.65	"	4.65	2925	6.50	0.650
12	6.75	Hg	919.0	11.2	Hg	3.34	"	6.00	3780	8.50	0.850

TABLE-3.B_{54}

System: Salt-air   Particle size: 52/60 BSS

h_s = 10 cms.   h= 25 cms.   R =2.5   t=21 °C

1	2		3	4		5		6	7	8	9
1	3.10	CCl_4	49.1	0.7	CCl_4	0.81	CCl_4	0.48	302	-	-
2	6.75	"	107.0	2.6	"	1.63	"	0.97	610	-	-
3	5.80	"	92.0	4.6	"	2.15	"	1.28	805	-	-
4	5.90	"	93.5	7.1	"	2.66	"	1.60	1007	-	-
5	6.10	"	96.7	15.8	"	3.97	"	2.39	1504	-	-
6	9.50	"	150.6	19.8	"	4.45	"	2.70	1700	-	-
7	12.50	"	198.0	28.0	"	5.30	"	3.20	2014	1.25	0.125
8	16.70	"	264.5	32.2	"	5.67	"	3.43	2160	2.25	0.225
9	19.70	"	312.0	38.6	"	6.21	"	3.76	2365	3.00	0.300
10	28.60	"	453.0	56.2	"	7.50	"	4.56	2870	4.00	0.400
11	3.60	Hg	490.0	8.2	Hg	2.86	Hg	5.15	3240	5.00	0.500
12	7.90	"	1074.0	16.9	"	4.11	"	7.40	4655	7.50	0.750

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{55} System: Salt-air Particle size: 52/60 BSS

h_s = 10 cms. h=30 cms. R =3.0 t=22°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.30	CCl_4	52.3	0.8	CCl_4	0.86	CCl_4	0.51	321	-	-
2	4.90	"	77.6	1.7	"	1.32	"	0.79	497	-	-
3	5.60	"	88.8	2.6	"	1.61	"	0.96	604	-	-
4	5.70	"	90.4	4.2	"	2.05	"	1.24	780	-	-
5	5.90	"	93.6	7.0	"	2.64	"	1.59	1000	-	-
6	6.20	"	98.4	15.5	"	3.94	"	2.39	1504	-	-
7	6.70	"	106.2	24.1	"	4.91	"	2.97	1870	-	-
8	15.30	"	242.5	36.1	"	6.00	"	3.64	2290	1.00	0.100
9	22.50	"	357.0	53.9	"	7.34	"	4.45	2800	2.75	0.275
10	3.40	Hg	462.0	8.8	Hg	2.96	Hg	5.34	3360	4.00	0.400
11	5.65	"	769.0	13.3	"	3.64	"	6.60	4150	5.00	0.500
12	7.40	"	1007.0	16.7	"	4.09	"	7.38	4650	6.00	0.600

TABLE.3.B_{56} System: Salt-air Particle size: 52/60 BSS

h_s = 10 cms. h= 35 cms. R = 3.5 t= 23°C

1	2		3	4		5		6	7	8	9
1	3.30	CCl_4	52.3	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	5.10	"	80.8	1.6	"	1.26	"	0.75	472	-	-
3	6.30	"	99.9	2.3	"	1.52	"	0.91	572	-	-
4	5.80	"	92.0	4.0	"	2.00	"	1.20	755	-	-
5	5.90	"	93.6	7.0	"	2.64	"	1.59	1000	-	-
6	6.10	"	96.7	12.0	"	3.46	"	2.10	1320	-	-
7	6.30	"	99.9	24.0	"	4.90	"	2.96	1862	-	-
8	10.10	"	160.0	34.1	"	5.94	"	3.60	2265	-	-
9	13.90	"	220.5	5.3	Hg	2.30	Hg	4.13	2600	1.0	0.100
10	21.50	"	341.0	6.9	"	2.63	"	4.71	2965	2.0	0.200
11	43.80	"	695.0	13.7	"	3.70	"	6.66	4190	4.0	0.400
12	7.80	Hg	1060.0	21.6	"	4.65	"	8.40	5290	5.0	0.500
13	10.10	"	1374.0	24.4	"	4.94	"	8.90	5600	6.0	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{57}

System: Salt-air Particle size: 52/60 BSS

h_s = 11 cms. h= 22 cms. R = 2.0 t = 21 °C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	4.10	CCl_4	65.0	0.8	CCl_4	0.89	CCl_4	0.53	334	-	-
2	5.80	"	92.0	1.8	"	1.32	"	0.81	510	-	-
3	6.10	"	96.7	2.7	"	1.64	"	0.98	616	-	-
4	6.30	"	99.9	4.5	"	2.12	"	1.28	805	-	-
5	6.50	"	103.0	8.3	"	2.88	"	1.74	1094	-	-
6	7.90	"	125.2	13.0	"	3.60	"	2.17	1366	-	-
7	9.90	"	157.0	15.2	"	3.90	"	2.35	1480	1.0	0.091
8	14.10	"	223.5	22.1	"	4.70	"	2.85	1792	2.2	0.200
9	20.40	"	323.5	27.7	"	5.26	"	3.19	2006	4.4	0.400
10	28.90	"	458.5	39.3	"	6.26	"	3.80	2380	5.5	0.500
11	38.40	"	609.0	51.1	"	7.15	"	4.35	2740	6.6	0.600
12	6.30	Hg	856.0	8.5	Hg	2.92	Hg	5.25	3300	7.7	0.700
13	10.70	"	1457.0	16.1	"	4.01	"	7.22	4550	8.8	0.800

TABLE-3.B_{58}

System: Salt-air Particle size: 52/60 BSS

h_s = 11 cms. h=27.5 cms. R= 2.5 t =23°C

1	2		3	4		5		6	7	8	9
1	2.40	CCl_4	38.0	0.5	CCl_4	0.71	CCl_4	0.42	264	-	-
2	5.10	"	80.8	1.4	"	1.18	"	0.70	440	-	-
3	6.30	"	99.9	2.1	"	1.43	"	0.85	535	-	-
4	6.30	"	99.9	4.5	"	2.12	"	1.28	805	-	-
5	6.70	"	106.2	14.9	"	3.86	"	2.33	1467	-	-
6	8.30	"	131.5	18.4	"	4.29	"	2.60	1635	-	-
7	11.10	"	176.0	24.8	"	4.98	"	3.00	1887	1.1	0.100
8	14.90	"	236.0	29.1	"	5.40	"	3.27	2060	2.0	0.182
9	21.40	"	339.5	39.2	"	6.26	"	3.80	2388	3.3	0.300
10	5.30	Hg	720.0	10.0	Hg	3.16	Hg	5.70	3585	5.5	0.500
11	7.20	"	980.0	13.6	"	3.68	"	6.63	4170	6.6	0.600
12	9.60	"	1305.0	18.2	"	4.26	"	7.68	4830	7.7	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{59}

System: Salt-air h_s = 11 cms. h=33 cms. Particle size: 52/60 BSS R=3.0 t = 24^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.90	CCl_4	61.9	0.8	CCl_4	0.89	CCl_4	0.53	334	-	-
2	4.90	"	77.6	1.2	"	1.10	"	0.65	409	-	-
3	6.10	"	96.7	1.6	"	1.26	"	0.75	472	-	-
4	6.20	"	98.4	3.0	"	1.73	"	1.04	654	-	-
5	6.30	"	99.9	4.6	"	2.14	"	1.29	811	-	-
6	6.70	"	106.2	16.0	"	4.00	"	2.41	1516	-	-
7	6.90	"	109.4	21.7	"	4.66	"	2.82	1773	-	-
8	8.70	"	138.0	26.1	"	5.11	"	3.10	1950	-	-
9	14.60	"	231.5	36.6	"	6.05	"	3.67	2306	1.5	0.136
10	24.70	"	392.0	49.4	"	7.03	"	4.27	2685	3.3	0.300
11	4.90	Hg	666.0	9.7	Hg	3.12	Hg	5.60	3520	4.4	0.400
12	6.70	"	911.0	14.2	"	3.77	"	6.78	4260	5.5	0.500
13	7.20	"	980.0	16.3	"	4.04	"	7.25	4560	6.6	0.600

TABLE-3.B_{60}

System: Salt-air h_s = 11 cms. h= 38.5 cms. Particle size: 52/60 BSS R = 3.5 t = 25^{o}C

1	2		3	4		5		6	7	8	9
1	3.10	CCl_4	49.2	0.6	CCl_4	0.78	CCl_4	0.45	283	-	-
2	3.95	"	62.6	1.0	"	1.00	"	0.60	378	-	-
3	6.05	"	96.0	2.2	"	1.48	"	0.89	560	-	-
4	6.25	"	99.2	3.7	"	1.92	"	1.15	723	-	-
5	6.45	"	102.2	8.0	"	2.83	"	1.70	1070	-	-
6	6.90	"	109.4	15.8	"	3.98	"	2.40	1510	-	-
7	11.10	"	176.0	38.7	"	6.22	"	3.77	2370	-	-
8	16.10	"	255.5	47.3	"	6.87	"	4.17	2625	1.5	0.136
9	3.10	Hg	421.5	7.5	Hg	2.74	Hg	4.90	3080	3.3	0.300
10	6.90	"	399.0	16.5	"	4.06	"	7.31	4600	5.5	0.500
11	10.90	"	1482.0	25.4	"	5.04	"	9.08	5710	6.6	0.600
12	13.10	"	1781.0	28.6	"	5.35	"	9.63	6055	7.7	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{61}

System: Salt-air Particle size: 52/60 BSS
h_s = 12 cms. h= 24 cms. R = 2.0 t= 26^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.10	CCl_4	49.2	0.15	CCl_4	0.39	CCl_4	0.22	138	-	-
2	5.30	"	84.0	0.65	"	0.81	"	0.48	302	-	-
3	6.80	"	107.8	1.60	"	1.26	"	0.75	472	-	-
4	7.10	"	112.5	4.40	"	2.10	"	1.26	792	-	-
5	9.90	"	157.0	12.60	"	3.55	"	2.15	1352	-	-
6	11.70	"	185.6	14.90	"	3.86	"	2.33	1467	1.2	0.100
7	16.70	"	265.0	19.50	"	4.42	"	2.67	1680	2.4	0.200
8	19.50	"	309.0	22.40	"	4.73	"	2.85	1792	3.0	0.250
9	26.20	"	415.0	28.00	"	5.30	"	3.20	2010	4.0	0.330
10	39.60	"	628.0	44.20	"	6.65	"	4.03	2540	6.0	0.500
11	6.40	Hg	870.0	7.20	Hg	2.68	Hg	4.82	3035	7.2	0.600
12	7.70	"	1048.0	8.50	"	2.91	"	5.25	3300	8.0	0.660

TABLE-3.B_{62}

System: Salt-air Particle size: 52/60 BSS
h_s =12 cms. h =30 cms. R=2.5 t = 20^{o}C

1	2		3	4		5		6	7	8	9
1	3.40	CCl_4	53.9	0.5	CCl_4	0.71	CCl_4	0.42	264	-	-
2	5.50	"	87.2	1.1	"	1.05	"	0.63	396	-	-
3	7.00	"	111.0	1.7	"	1.30	"	0.78	491	-	-
4	7.10	"	112.5	3.3	"	1.81	"	1.09	685	-	-
5	7.20	"	114.2	5.7	"	2.48	"	1.50	944	-	-
6	7.40	"	117.3	12.1	"	3.48	"	2.10	1320	-	-
7	10.10	"	160.0	18.4	"	4.29	"	2.59	1630	-	-
8	14.70	"	233.0	25.2	"	5.02	"	3.03	1908	1.5	0.125
9	25.40	"	402.5	33.2	"	5.76	"	3.50	2200	3.0	0.250
10	33.70	"	535.0	41.2	"	6.42	"	3.90	2455	4.0	0.333
11	6.60	Hg	897.5	8.0	Hg	2.83	Hg	5.10	3208	6.0	0.500
12	11.00	"	1497.0	15.9	"	3.98	"	7.15	4500	7.2	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES.

TABLE-3.B_{63}

System: Salt-air Particle size: 52/60 BSS
h_s = 12 cms. h= 36 cms R= 3.0 t= 21 ^{o}C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{1/2}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.60 CCl_4	57.1	0.7 CCl_4	0.84 CCl_4	0.49	308	-	-
2	4.90 "	77.6	1.1 "	1.05 "	0.62	393	-	-
3	6.60 "	104.6	1.7 "	1.30 "	0.78	491	-	-
4	6.80 "	107.8	2.7 "	1.64 "	0.98	616	-	-
5	7.00 "	111.0	5.3 "	2.30 "	1.38	868	-	-
6	7.10 "	112.5	9.0 "	3.00 "	1.80	1131	-	-
7	7.40 "	117.3	20.2 "	4.50 "	2.72	1710	-	-
8	11.40 "	181.0	26.1 "	5.11 "	3.10	1950	-	-
9	13.40 "	212.5	34.0 "	5.83 "	3.53	2220	1.0	0.083
10	23.50 "	372.5	48.2 "	6.95 "	4.22	2655	3.5	0.292
11	4.30 Hg	585.0	8.4 Hg	2.90 "	5.21	3280	4.8	0.400
12	6.50 "	885.0	13.5 "	3.68 "	6.60	4150	6.0	0.500

TABLE-3.B_{64}

System : Salt-air Particle size: 52/60 BSS
h_s = 12 cms. h =42 cms. R= 3.5 t =22 ^{o}C

1	2	3	4	5	6	7	8	9
1	3.20 CCl_4	50.7	0.5 CCl_4	0.71 CCl_4	0.42	264	-	-
2	5.20 "	82.5	1.1 "	1.05 "	0.62	390	-	-
3	6.80 "	107.8	1.7 "	1.32 "	0.80	504	-	-
4	6.80 "	107.8	2.8 "	1.67 "	1.00	629	-	-
5	7.20 "	114.2	8.6 "	2.93 "	1.76	1107	-	-
6	7.40 "	117.3	15.7 "	3.96 "	2.40	1510	-	-
7	7.60 "	120.5	22.9 "	4.79 "	2.90	1825	-	-
8	12.00 "	190.2	33.4 "	5.78 "	3.50	2200	-	-
9	17.30 "	274.0	43.8 "	6.61 "	4.01	2525	1.8	0.150
10	3.60 Hg	490.0	8.4 Hg	2.90 Hg	5.21	3280	3.0	0.250
11	7.20 "	980.0	15.3 "	3.91 "	7.04	4425	4.8	0.400
12	9.50 "	1290.0	20.8 "	4.56 "	8.22	5170	6.0	0.500
13	13.80 "	1880.0	27.2 "	5.22 "	9.40	5910	7.5	0.625

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{65}

System: Ammonium sulphate-air Particle size: 30/40 BSS
h_s = 9 cms. h = 18 cms. R= 2.0 t= 18^{o}C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.60 CCl_4	57.0	0.7 CCl_4	0.84 CCl_4	0.50	314	-	-
2	6.00 "	95.0	2.0 "	1.41 "	0.85	535	-	-
3	7.00 "	111.0	4.0 "	2.00 "	1.20	755	-	-
4	6.10 "	96.6	8.1 "	2.84 "	1.72	1082	-	-
5	6.30 "	99.9	15.0 "	3.87 "	2.34	1470	-	-
6	6.50 "	103.0	20.2 "	4.49 "	2.70	1700	-	-
7	9.50 "	150.6	25.2 "	5.02 "	3.03	1908	-	-
8	16.50 "	261.5	32.6 "	5.71 "	3.45	2172	1.5	0.166
9	24.50 "	388.0	43.0 "	6.55 "	3.97	2500	2.7	0.300
10	32.50 "	515.0	55.3 "	7.44 "	4.51	2840	3.6	0.400
11	5.10 Hg	694.0	8.4 Hg	2.90 Hg	5.21	3280	4.5	0.500
12	7.90 "	1075.0	12.3 "	3.50 "	6.30	3960	6.0	0.666
13	14.10 "	1918.0	22.3 "	4.72 "	8.50	5350	7.2	0.800

TABLE-3.B_{66}

System: Ammonium sulphate-air Particle size: 30/40 BSS
h_s = 9 cms. h = 22.5 cms. R=2.5 t= 19^{o}C

1	2	3	4	5	6	7	8	9
1	3.00 CCl_4	47.5	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	4.80 "	76.0	1.4 "	1.18 "	0.70	440	-	-
3	6.70 "	106.2	3.1 "	1.76 "	1.05	660	-	-
4	6.15 "	97.5	7.5 "	2.74 "	1.65	1039	-	-
5	6.35 "	100.8	16.9 "	4.11 "	2.49	1568	-	-
6	6.45 "	102.2	21.2 "	4.60 "	2.78	1750	-	-
7	6.55 "	103.8	33.3 "	5.76 "	3.50	2205	-	-
8	7.55 "	119.7	39.5 "	6.29 "	3.82	2405	-	-
9	17.00 "	269.5	52.4 "	7.25 "	4.40	2770	1.5	0.166
10	4.10 Hg	557.5	10.5 Hg	3.24 Hg	5.90	3715	3.6	0.400
11	6.40 "	856.0	15.5 "	3.94 "	7.08	4455	4.5	0.500
12	9.60 "	1306.0	20.7 "	4.55 "	8.20	5160	5.4	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{67}

System: Ammonium sulphate-air Particle size: 30/40 BSS
h_s = 9 cms. h =27 cms. R=3.0 t = 20°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.30 CCl_4	36.4	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	4.10 "	65.0	1.5 "	1.22 "	0.72	453	-	-
3	5.30 "	84.0	2.5 "	1.58 "	0.95	597	-	-
4	6.10 "	96.6	6.1 "	2.47 "	1.49	936	-	-
5	6.30 "	99.9	18.1 "	4.25 "	2.57	1618	-	-
6	6.50 "	103.0	30.1 "	5.48 "	3.32	2090	-	-
7	6.60 "	104.6	39.6 "	6.30 "	3.82	2400	-	-
8	10.30 "	163.0	56.0 "	7.48 "	4.55	2860	-	-
9	1.60 Hg	217.5	8.2 Hg	2.86 Hg	5.15	3240	1.5	0.166
10	3.30 "	449.0	13.7 "	3.70 "	6.65	4185	3.3	0.366
11	7.00 "	952.0	22.6 "	4.75 "	8.56	5390	4.5	0.500
12	12.80 "	1740.0	34.1 "	5.84 "	10.50	6600	6.0	0.666

TABLE-3.B_{68}

System: Ammonium sulphate-air Particle size; 30/40 BSS
h_s = 9 cms. h =31.5 cms. R=3.5 t= 21°C

1	2	3	4	5	6	7	8	9
1	2.50 CCl_4	39.6	0.7 CCl_4	0.84 CCl_4	0.49	308	-	-
2	5.10 "	80.8	2.4 "	1.55 "	0.93	585	-	-
3	5.50 "	87.0	3.6 "	1.89 "	1.14	716	-	-
4	5.80 "	92.0	6.0 "	2.45 "	1.47	925	-	-
5	5.90 "	93.5	9.9 "	3.14 "	1.90	1195	-	-
6	6.30 "	99.9	25.6 "	5.06 "	3.06	1925	-	-
7	6.50 "	103.0	43.0 "	6.55 "	3.97	2500	-	-
8	6.70 "	106.1	55.4 "	7.44 "	4.50	2830	-	-
9	1.10 Hg	149.7	7.9 Hg	2.81 Hg	5.04	3170	-	-
10	2.60 "	353.5	12.4 "	3.52 "	6.34	3985	1.2	0.133
11	4.70 "	639.5	16.5 "	4.06 "	7.31	4600	2.7	0.300
12	7.20 "	980.0	23.7 "	4.86 "	8.75	5500	3.6	0.400
13	12.00 "	1632.0	33.1 "	5.75 "	10.35	6500	4.8	0.533

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{69}

System: Ammonium sulphate-air Particle size: 30/40 BSS
h_s = 10 cms. h= 20 cms. R= 2.0 t= 23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.90 CCl_4	46.0	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	5.70 "	90.3	1.6 "	1.26 "	0.75	472	-	-
3	8.70 "	138.0	3.6 "	1.89 "	1.15	723	-	-
4	10.10 "	160.0	7.7 "	2.78 "	1.67	1050	-	-
5	6.70 "	106.1	10.3 "	3.21 "	1.94	1220	-	-
6	6.90 "	109.3	20.6 "	4.54 "	2.74	1725	-	-
7	8.50 "	134.8	25.4 "	5.04 "	3.04	1915	-	-
8	14.10 "	223.5	30.1 "	5.49 "	3.31	2082	1.50	0.150
9	19.00 "	301.0	37.5 "	6.12 "	3.70	2327	2.50	0.250
10	23.60 "	374.0	47.8 "	6.91 "	4.20	2640	3.50	0.350
11	3.70 Hg	503.0	7.0 Hg	2.65 Hg	4.78	3010	4.50	0.450
12	4.90 "	666.0	8.6 "	2.93 "	5.27	3320	5.50	0.550
13	7.40 "	1007.0	12.6 "	3.55 "	6.40	4030	6.50	0.650
14	10.80 "	1470.0	18.0 "	4.25 "	7.65	4810	7.50	0.750

TABLE-3.B_{70}

System: Ammonium sulphate-air Particle size: 30/40 BSS
h_s = 10 cms. h =25 cms. R= 2.5 t = 23°C

1	2	3	4	5	6	7	8	9
1	1.60 CCl_4	25.4	0.3 CCl_4	0.55 CCl_4	0.32	202	-	-
2	3.90 "	61.8	1.5 "	1.22 "	0.73	460	-	-
3	6.15 "	97.5	3.2 "	1.79 "	1.06	666	-	-
4	6.60 "	104.6	8.2 "	2.86 "	1.74	1095	-	-
5	6.80 "	107.8	15.0 "	3.87 "	2.33	1466	-	-
6	7.10 "	112.5	29.4 "	5.41 "	3.27	2060	-	-
7	10.20 "	161.8	33.5 "	5.79 "	3.50	2200	-	-
8	13.80 "	218.5	50.5 "	7.10 "	4.30	2705	1.50	0.150
9	3.00 Hg	408.0	7.4 Hg	2.72 Hg	4.90	3080	2.75	0.275
10	4.20 "	571.0	10.6 "	3.25 "	5.86	3690	3.75	0.375
11	6.60 "	897.0	14.9 "	3.86 "	6.95	4370	5.00	0.500
12	9.80 "	1332.0	20.6 "	4.54 "	8.16	5140	6.00	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{71}

System: Ammonium sulphate-air   Particle size: 30/40 BSS
h_s =10 cms.   h = 30 cms.   R = 3.0   t = 24 °C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	2.30	CCl_4	36.4	0.6	CCl_4	0.78	CCl_4	0.45	283	-	-
2	3.50	"	55.5	1.2	"	1.10	"	0.65	409	-	-
3	5.70	"	90.4	3.0	"	1.73	"	1.04	654	-	-
4	6.60	"	104.6	6.3	"	2.51	"	1.51	950	-	-
5	6.60	"	104.6	11.4	"	3.38	"	2.03	1277	-	-
6	6.80	"	107.8	21.1	"	4.60	"	2.78	1750	-	-
7	7.00	"	111.0	34.2	"	5.85	"	3.55	2535	-	-
8	8.00	"	127.0	53.1	"	7.29	"	4.43	2785	-	-
9	2.90	Hg	394.0	10.6	Hg	3.25	Hg	5.86	3685	2.00	0.20
10	4.50	"	612.0	14.1	"	3.74	"	6.71	4230	3.00	0.30
11	7.40	"	1007.0	20.7	"	4.55	"	8.20	5160	4.50	0.45
12	10.50	"	1428.0	27.8	"	5.27	"	9.50	5980	5.50	0.55

TABLE-3.B_{72}

System: Ammonium sulphate-air   Particle size: 30/40 BSS
h_s = 10 cms.   h = 35 cms.   R = 3.5   t= 24°C

1	2		3	4		5		6	7	8	9
1	1.80	CCl_4	28.5	0.4	CCl_4	0.63	CCl_4	0.37	233	-	-
2	4.10	"	65.0	1.6	"	1.26	"	0.75	472	-	-
3	5.70	"	90.4	3.0	"	1.73	"	1.04	654	-	-
4	6.60	"	104.6	9.9	"	3.14	"	1.90	1196	-	-
5	6.80	"	107.8	21.5	"	4.64	"	2.80	1760	-	-
6	7.00	"	111.0	37.8	"	6.15	"	3.73	2346	-	-
7	7.20	"	114.1	50.3	"	7.10	"	4.30	2706	-	-
8	1.10	Hg	149.7	8.0	Hg	2.83	Hg	5.10	3210	-	-
9	2.20	"	299.0	11.6	"	3.40	"	6.10	3840	1.00	0.10
10	3.50	"	476.0	16.7	"	4.09	"	7.35	4620	2.50	0.25
11	5.70	"	775.0	22.4	"	4.74	"	8.54	5370	4.00	0.40
12	12.50	"	1700.0	36.5	"	6.05	"	10.90	6850	5.30	0.53

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{73}

System: Ammonium sulphate-air   Particle size: 30/40 BSS
h_s = 11 cms.   h = 22 cms   R= 2.0   t= 21°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.00 CCl_4	47.5	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	6.20 "	98.2	1.7 "	1.30 "	0.77	485	-	-
3	8.20 "	130.0	2.9 "	1.70 "	1.02	641	-	-
4	7.20 "	114.1	5.8 "	2.41 "	1.45	911	-	-
5	7.50 "	119.0	13.1 "	3.62 "	2.18	1370	-	-
6	7.60 "	120.6	17.2 "	4.15 "	2.50	1570	-	-
7	7.70 "	122.1	21.6 "	4.65 "	2.81	1768	-	-
8	12.10 "	192.0	28.2 "	5.31 "	3.21	2020	1.10	0.100
9	19.10 "	302.5	35.5 "	5.96 "	3.61	2270	3.00	0.272
10	25.80 "	409.0	50.1 "	7.09 "	4.30	2705	4.00	0.364
11	4.90 Hg	666.0	9.0 Hg	3.00 "	5.40	3400	6.00	0.545
12	7.40 "	1007.0	12.1 "	3.48 "	6.26	3940	7.00	0.636
13	11.50 "	1563.0	18.6 "	4.31 "	7.77	4890	8.00	0.726

TABLE-3.B_{74}

System: Ammonium sulphate-air   Particle size: 30/40 BSS
h_s = 11 cms.   h = 27.5   R= 2.5   t = 23°C

1	2	3	4	5	6	7	8	9
1	2.60 CCl_4	41.2	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	5.20 "	82.4	1.8 "	1.34 "	0.80	503	-	-
3	7.00 "	111.0	3.8 "	1.95 "	1.17	735	-	-
4	7.10 "	112.6	6.5 "	2.55 "	1.55	975	-	-
5	7.20 "	114.1	11.1 "	3.33 "	2.00	1258	-	-
6	7.40 "	117.2	17.6 "	4.20 "	2.53	1590	-	-
7	7.60 "	120.6	32.1 "	5.66 "	3.43	2160	-	-
8	9.40 "	149.0	36.7 "	6.06 "	3.67	2306	-	-
9	15.40 "	244.0	50.4 "	7.10 "	4.30	2702	2.50	0.227
10	3.00 Hg	408.0	9.6 Hg	3.10 Hg	5.60	3520	4.00	0.364
11	4.80 "	653.0	13.9 "	3.73 "	6.70	4210	5.50	0.500
12	12.70 "	1728.0	29.5 "	5.43 "	9.77	6150	7.70	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{75}

System: Ammonium sulphate-air Partifle size: 30/40 BSS
h_s = 11 cms. h = 33 cms. R= 3.0 t= 24°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.00 CCl_4	31.7	0.4 CCl_4	0.63 CCl_4	0.37	233	-	-
2	4.40 "	69.7	1.5 "	1.22 "	0.72	452	-	-
3	6.00 "	95.1	2.7 "	1.64 "	0.98	616	-	-
4	7.00 "	111.0	5.5 "	2.34 "	1.40	880	-	-
5	7.10 "	112.6	8.8 "	2.97 "	1.79	1125	-	-
6	7.30 "	115.8	16.5 "	4.06 "	2.46	1548	-	-
7	7.60 "	120.6	29.8 "	5.45 "	3.30	2075	-	-
8	7.80 "	123.8	45.3 "	6.73 "	4.08	2565	-	-
9	1.50 Hg	204.0	7.8 Hg	2.79 Hg	5.04	3165	-	-
10	2.60 "	354.0	10.4 "	3.22 "	5.80	3650	2.2	0.200
11	4.00 "	544.0	14.9 "	3.86 "	6.95	4370	3.5	0.318
12	5.30 "	720.0	19.6 "	4.43 "	7.96	5010	5.0	0.455
13	10.60 "	1440.0	31.3 "	5.60 "	10.10	6350	6.6	0.600

TABLE-3.B_{76}

System: Ammonium sulphate-air Particle size: 30/40 BSS
h_s = 11 cms. h= 38.5 cms. R = 3.5 t= 24°C

1	2	3	4	5	6	7	8	9
1	2.60 CCl_4	41.2	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	3.80 "	60.2	1.2 "	1.10 "	0.65	409	-	-
3	6.60 "	104.6	3.4 "	1.84 "	1.10	691	-	-
4	7.00 "	111.0	6.1 "	2.47 "	1.49	936	-	-
5	7.40 "	117.3	24.3 "	4.93 "	2.98	1873	-	-
6	7.80 "	123.8	55.7 "	7.45 "	4.52	2840	-	-
7	1.30 Hg	177.0	9.4 Hg	3.06 Hg	5.52	3475	-	-
8	3.60 "	490.0	15.1 "	3.88 "	7.00	4400	1.5	0.136
9	4.50 "	612.0	17.6 "	4.19 "	7.55	4750	2.5	0.227
10	6.20 "	843.0	22.1 "	4.70 "	8.48	5340	3.5	0.318
11	10.80 "	1470.0	29.5 "	5.43 "	9.77	6150	4.5	0.409
12	14.40 "	1960.0	39.2 "	6.26 "	11.30	7100	5.5	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{77}

System: Ammonium sulphate-air Particle size: 30/40 BSS

h_s = 12 cms. h = 24 cms R = 2.0 t = 25°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	4.20 CCl_4	66.6	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	5.80 "	92.0	1.2 "	1.10 "	0.65	409	-	-
3	9.60 "	152.1	3.2 "	1.79 "	1.07	673	-	-
4	7.80 "	123.8	5.4 "	2.32 "	1.40	880	-	-
5	7.90 "	125.2	9.1 "	3.02 "	1.82	1144	-	-
6	8.10 "	128.4	15.8 "	3.97 "	2.40	1510	-	-
7	10.20 "	161.8	26.0 "	5.10 "	3.08	1938	-	-
8	13.90 "	220.4	31.7 "	5.63 "	3.41	2145	2.40	0.200
9	20.30 "	322.0	42.3 "	6.50 "	3.95	2485	4.00	0.334
10	4.40 Hg	599.0	8.7 Hg	2.95 Hg	5.30	3330	6.00	0.500
11	7.30 "	993.0	13.4 "	3.66 "	6.60	4150	7.50	0.625
12	12.10 "	1646.0	19.5 "	4.41 "	7.95	5000	9.00	0.750

TABLE-3.B_{78}

System: Ammonium sulphate-air Particle size: 30/40 BSS

h_s = 12 cms. h = 30 cms. R = 2.5 t = 26°C

1	2	3	4	5	6	7	8	9
1	2.70 CCl_4	42.8	0.4 CCl_4	0.63 CCl_4	0.37	233	-	-
2	4.10 "	65.0	1.0 "	1.00 "	0.60	377	-	-
3	7.50 "	119.0	3.6 "	1.90 "	1.14	654	-	-
4	7.90 "	125.2	6.2 "	2.49 "	1.50	943	-	-
5	8.00 "	126.8	10.0 "	3.16 "	1.91	1200	-	-
6	8.10 "	128.4	15.3 "	3.91 "	2.36	1484	-	-
7	8.30 "	131.7	25.5 "	5.05 "	3.05	1920	-	-
8	11.50 "	182.2	37.5 "	6.12 "	3.70	2326	-	-
9	2.30 Hg	312.8	6.2 Hg	2.49 Hg	4.48	2820	1.80	0.150
10	2.90 "	394.0	7.6 "	2.76 "	4.98	3135	3.00	0.250
11	4.20 "	571.0	11.6 "	3.40 "	6.10	3840	4.50	0.375
12	5.30 "	720.0	14.7 "	3.84 "	6.90	4340	6.00	0.500
13	11.80 "	1605.0	25.4 "	5.05 "	9.10	5720	8.00	0.666

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B79

System: Ammonium sulphate-air   Particle size: 30/40 BSS
h_s = 12 cms.   h = 36 cms   R = 3.0   t =26°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.0 CCl_4	47.5	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	5.20 "	82.4	1.6 "	1.25 "	0.75	472	-	-
3	6.80 "	107.8	2.6 "	1.61 "	0.94	591	-	-
4	7.70 "	122.0	4.6 "	2.14 "	1.29	810	-	-
5	8.10 "	128.3	18.5 "	4.30 "	2.60	1635	-	-
6	8.30 "	131.5	42.5 "	6.51 "	3.95	2485	-	-
7	1.30 Hg	177.0	7.3 Hg	2.70 "	4.86	3060	-	-
8	2.30 "	312.8	8.4 "	2.90 "	5.20	3270	1.2	0.100
9	2.90 "	394.0	10.2 "	3.19 "	5.73	3605	2.5	0.208
10	4.60 "	625.0	14.5 "	3.81 "	6.82	4295	4.0	0.333
11	7.20 "	980.0	19.8 "	4.45 "	8.00	5035	5.4	0.450
12	11.60 "	1578.0	28.6 "	5.35 "	9.63	6055	6.6	0.550

TABLE-3.B80

System: Ammonium sulphate-air   Particle size: 30/40 BSS
h_s = 12 cms.   h= 42 cms.   R = 3.5   t = 26°C

1	2	3	4	5	6	7	8	9
1	2.60 CCl_4	41.2	0.4 CCl_4	0.63 CCl_4	0.37	233	-	-
2	4.90 "	77.6	1.5 "	1.22 "	0.73	459	-	-
3	6.90 "	109.3	2.8 "	1.67 "	1.00	629	-	-
4	7.9 "	125.1	6.7 "	2.58 "	1.55	975	-	-
5	8.10 "	128.3	14.9 "	3.86 "	2.34	1471	-	-
6	8.30 "	131.5	24.2 "	4.92 "	2.97	1870	-	-
7	8.50 "	134.7	47.6 "	6.90 "	4.20	2640	-	-
8	1.00 Hg	136.0	7.7 Hg	2.77 Hg	5.00	3145	-	-
9	1.40 "	190.5	9.7 "	3.11 "	5.60	3520	-	-
10	2.70 "	367.0	12.3 "	3.51 "	6.32	3980	1.2	0.100
11	4.60 "	625.0	16.7 "	4.09 "	7.35	4620	2.4	0.200
12	5.40 "	735.0	23.1 "	4.81 "	8.67	5450	4.0	0.333
13	12.30 "	1673.0	36.6 "	6.05 "	10.90	6850	6.3	0.525

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{81}

System: Sand-air Particle size: 30/40 BSS

h_s = 9 cms. h= 18 cms. R =2.0 t= 20°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.5 CCl_4	55.5	0.9 CCl_4	0.95 CCl_4	0.55	346	-	-
2	5.9 "	93.5	2.4 "	1.55 "	0.94	591	-	-
3	7.1 "	112.6	3.4 "	1.84 "	1.10	691	-	-
4	7.9 "	125.1	7.3 "	2.70 "	1.63	1025	-	-
5	8.1 "	128.3	14.9 "	3.86 "	2.34	1471	-	-
6	8.3 "	131.5	25.6 "	5.06 "	3.06	1925	-	-
7	10.9 "	173.0	29.9 "	5.46 "	3.30	2075	-	-
8	14.7 "	233.0	35.8 "	5.98 "	3.62	2280	1.5	0.166
9	17.1 "	271.0	40.5 "	6.36 "	3.86	2430	2.0	0.222
10	21.1 "	334.5	49.4 "	7.03 "	4.26	2680	3.0	0.333
11	2.9 Hg	394.0	6.6 Hg	2.57 Hg	4.62	2908	4.0	0.444
12	5.1 "	694.0	11.7 "	3.42 "	6.15	3870	5.4	0.600
13	8.0 "	1089.0	18.7 "	4.33 "	7.80	4905	6.3	0.700

TABLE-3.B_{82}

System: Sand-air Particle size: 30/40 BSS

h_s = 9 cms. h= 22.5 cms. R =2.5 t= 21°C

1	2	3	4	5	6	7	8	9
1	1.7 CCl_4	26.9	0.3 CCl_4	0.55 CCl_4	0.32	201	-	-
2	4.1 "	65.0	1.5 "	1.22 "	0.73	459	-	-
3	7.3 "	115.8	4.5 "	2.12 "	1.27	798	-	-
4	7.7 "	122.0	8.2 "	2.86 "	1.73	1090	-	-
5	8.1 "	128.3	23.5 "	4.85 "	2.94	1850	-	-
6	8.3 "	131.5	31.5 "	5.61 "	3.40	2140	-	-
7	9.1 "	144.2	35.5 "	5.95 "	3.60	2264	-	-
8	16.3 "	258.5	47.1 "	6.86 "	4.16	2620	1.5	0.166
9	3.0 Hg	408.0	9.7 Hg	3.12 "	5.60	3520	3.3	0.367
10	4.9 "	666.0	15.6 "	3.95 "	7.10	4470	4.5	0.500
11	7.1 "	965.0	22.5 "	4.75 "	8.55	5380	5.4	0.600
12	10.7 "	1455.0	31.6 "	5.62 "	10.12	6365	6.3	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{83}

System: Sand-air Particle size: 30/40 BSS
h_s = 9 cms. h = 27 cms. R = 3.0 t= 22 ^oC

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.1 CCl_4	33.3	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	4.1 "	65.0	2.0 "	1.41 "	0.85	535	-	-
3	7.3 "	115.8	5.6 "	2.36 "	1.42	892	-	-
4	7.9 "	125.1	10.6 "	3.26 "	1.96	1232	-	-
5	8.1 "	128.3	18.8 "	4.34 "	2.62	1650	-	-
6	8.2 "	130.0	26.3 "	5.12 "	3.10	1950	-	-
7	8.3 "	131.5	38.1 "	6.17 "	3.74	2355	-	-
8	13.9 "	220.5	48.8 "	6.99 "	4.24	2666	-	-
9	1.8 Hg	244.6	6.6 Hg	2.57 Hg	4.62	2908	1.0	0.111
10	2.2 "	299.0	7.4 "	2.72 "	4.90	3080	2.0	0.222
11	4.7 "	640.0	16.8 "	4.10 "	7.40	4650	4.0	0.444
12	7.8 "	1061.0	28.1 "	5.30 "	9.56	6015	4.8	0.534
13	10.7 "	1455.0	36.4 "	6.03 "	10.86	6825	5.4	0.600

TABLE-3.B_{84}

System: Sand-air Particle size: 30/40 BSS
h_s = 9 cms. h=31.5 cms. R= 3.5 t = 23^{o}C

1	2	3	4	5	6	7	8	9
1	2.5 CCl_4	39.6	0.7 CCl_4	0.84 CCl_4	0.49	308	-	-
2	4.1 "	65.0	1.8 "	1.34 "	0.80	504	-	-
3	5.5 "	71.4	3.4 "	1.84 "	1.10	691	-	-
4	8.1 "	128.3	7.0 "	2.64 "	1.60	1017	-	-
5	7.9 "	125.1	13.8 "	3.72 "	2.25	1418	-	-
6	8.1 "	128.3	24.5 "	4.95 "	3.00	1887	-	-
7	8.5 "	134.7	32.0 "	5.65 "	3.42	2152	-	-
8	8.9 "	141.0	48.7 "	6.98 "	4.24	2666	-	-
9	1.6 Hg	217.5	7.4 Hg	2.72 Hg	4.90	3080	-	-
10	2.4 "	326.5	9.2 "	3.03 "	5.45	3420	1.2	0.133
11	3.6 "	490.0	13.1 "	3.62 "	6.50	4090	2.7	0.300
12	5.5 "	748.0	22.5 "	4.75 "	8.55	5380	3.6	0.400
13	7.9 "	1075.0	31.2 "	5.59 "	10.05	6315	4.5	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

.E-3.B_{85}

System: Sand-air Particle size: 30/40 BSS
h_s = 10 cms. h= 20 cms. R= 2.0 t = 23°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M²	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{1/2}$		W Kg/hr.	G Kg/hr.m²	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.3	CCl_4	52.3	0.6	CCl_4	0.77	CCl_4	0.45	283	-	-
2	6.1	"	96.7	2.0	"	1.41	"	0.85	535	-	-
3	9.7	"	153.8	5.0	"	2.23	"	1.34	842	-	-
4	8.5	"	134.7	9.4	"	3.06	"	1.85	1162	-	-
5	8.8	"	139.5	16.6	"	4.07	"	2.46	1548	-	-
6	8.9	"	141.0	21.9	"	4.67	"	2.82	1772	-	-
7	10.7	"	169.7	24.7	"	4.97	"	3.00	1887	-	-
8	14.3	"	226.7	27.9	"	5.28		3.20	2010	1.0	0.10
9	19.9	"	315.5	37.3	"	6.10	"	3.70	2325	2.5	0.25
10	25.1	"	398.0	47.1	"	6.86	"	4.16	2620	4.0	0.40
11	4.0	Hg	544.0	7.8	Hg	2.79	Hg	5.01	3155	5.0	0.50
12	6.2	"	844.0	12.9	"	3.59	"	6.45	4050	6.0	0.60
13	10.2	"	1388.0	21.1	"	4.60	"	8.30	5220	7.2	0.72

TABLE-3.B_{86}

System: Sand-air Particle size: 30/40 BSS
h_s=10 cms. h= 25 cms. R = 2.5 t = 24°C

1	2		3	4		5		6	7	8	9
1	2.6	CCl_4	41.2	0.7	CCl_4	0.84	CCl_4	0.49	308	-	-
2	4.8	"	76.1	2.4	"	1.55	"	0.93	585	-	-
3	6.6	"	104.6	4.2	"	2.05	"	1.23	774	-	-
4	8.0	"	126.8	6.5	"	2.55	"	1.55	975	-	-
5	8.8	"	139.5	14.8	"	3.84	"	2.33	1465	-	-
6	9.0	"	142.7	20.1	"	4.49	"	2.70	1700	-	-
7	9.3	"	147.0	31.2	"	5.59	"	3.38	2125	-	-
8	13.0	"	206.0	34.9	"	5.90	"	3.57	2245	-	-
9	17.2	"	272.5	39.7	"	6.30	"	3.82	2400	1.8	0.18
10	21.8	"	346.0	50.5	"	7.10	"	4.30	2700	3.0	0.30
11	3.4	Hg	462.0	7.6	Hg	2.75	Hg	5.00	3145	4.0	0.40
12	4.5	"	612.0	9.9	"	3.14	"	5.68	3552	5.0	0.50
13	9.1	"	1239.0	23.8	"	4.88	"	8.80	5540	6.5	0.65

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

LE-3.B_{87}

System: Sand-air Particle size : 30/40 BSS
h_s = 10 cms. h = 30 cms. R =3.0 t = 26°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.0 CCl_4	31.7	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	4.5 "	71.4	2.2 "	1.48 "	0.89	560	-	-
3	6.3 "	99.9	4.2 "	2.05 "	1.23	774	-	-
4	8.7 "	138.0	10.4 "	3.22 "	1.95	1225	-	-
5	8.9 "	141.0	15.8 "	3.98 "	2.40	1510	-	-
6	9.1 "	144.2	22.8 "	4.77 "	2.89	1820	-	-
7	9.5 "	150.6	39.0 "	6.25 "	3.80	2390	-	-
8	1.3 Hg	177.0	4.9 Hg	2.21 Hg	4.00	2515	-	-
9	2.2 "	299.0	6.5 "	2.55 "	4.60	2895	1.5	0.15
10	3.1 "	421.0	8.7 "	2.95 "	5.30	3335	3.0	0.30
11	3.8 "	517.0	11.2 "	3.35 "	6.01	3780	4.0	0.40
12	6.3 "	856.0	21.6 "	4.65 "	8.40	5290	5.0	0.50
13	8.9 "	1210.0	28.8 "	5.36 "	9.66	6090	6.2	0.62

TABLE-3.B_{88}

System: Sand-air Particle size: 30/40 BSS
h_s = 10 cms. h= 35 cms. R= 3.5 t= 26°C

1	2	3	4	5	6	7	8	9
1	2.9 CCl_4	46.0	0.8 CCl_4	0.89 CCl_4	0.53	333	-	-
2	4.4 "	69.7	1.8 "	1.34 "	0.80	504	-	-
3	5.6 "	88.7	2.8 "	1.67 "	1.00	629	-	-
4	6.4 "	101.4	3.8 "	1.95 "	1.17	735	-	-
5	8.8 "	139.4	12.7 "	3.56 "	2.15	1352	-	-
6	9.1 "	144.2	21.5 "	4.64 "	2.80	1760	-	-
7	9.4 "	149.0	49.2 "	7.01 "	4.25	2672	-	-
8	1.5 Hg	204.4	7.0 Hg	2.64 Hg	4.74	2980	-	-
9	2.3 "	312.8	8.7 "	2.95 "	5.30	3335	1.8	0.18
10	3.4 "	462.0	12.1 "	3.48 "	6.25	3930	3.0	0.30
11	5.3 "	720.0	15.9 "	3.98 "	7.15	4500	4.5	0.45
12	9.1 "	1239.0	34.2 "	5.85 "	10.51	6605	6.0	0.60

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{89}

System: Sand-air Particle size: 30/40 BSS
h_s = 11 cms. h= 22 cms. R= 2.0 t= 22°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.2 CCl_4	50.7	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	5.4 "	85.5	1.6 "	1.26 "	0.75	471	-	-
3	8.8 "	139.4	3.8 "	1.96 "	1.18	741	-	-
4	9.6 "	152.0	9.6 "	3.10 "	1.87	1178	-	-
5	9.9 "	156.9	21.2 "	4.60 "	2.78	1750	-	-
6	12.8 "	202.8	24.6 "	4.96 "	3.00	1887	-	-
7	14.0 "	222.0	26.5 "	5.15 "	3.11	1958	1.0	0.091
8	17.4 "	276.0	32.6 "	5.71 "	3.45	2170	2.2	0.200
9	21.2 "	336.0	42.2 "	6.50 "	3.95	2485	3.0	0.272
10	28.8 "	456.0	51.9 "	7.20 "	4.37	2750	4.4	0.400
11	4.9 Hg	666.0	9.5 Hg	3.08 Hg	5.54	3480	6.0	0.545
12	6.2 "	824.0	12.3 "	3.50 "	6.30	3960	7.0	0.636
13	8.6 "	1170.0	17.7 "	4.20 "	7.55	4750	8.0	0.726

TABLE-3.B_{90}

System: Sand-air Particle size: 30/40 BSS
h_s = 11 cms. h= 27.5 cms. R= 2.5 t = 22°C

1	2	3	4	5	6	7	8	9
1	3.2 CCl_4	50.7	0.8 CCl_4	0.89 CCl_4	0.53	333	-	-
2	5.6 "	88.7	2.2 "	1.48 "	0.89	560	-	-
3	8.4 "	133.0	5.1 "	2.26 "	1.36	855	-	-
4	9.8 "	155.2	11.0 "	3.32 "	2.00	1258	-	-
5	10.3 "	163.0	26.5 "	5.15 "	3.11	1960	-	-
6	11.8 "	187.0	29.0 "	5.38 "	3.25	2045	-	-
7	14.2 "	224.8	35.3 "	5.94 "	3.60	2265	1.4	0.127
8	18.6 "	294.5	40.0 "	6.32 "	3.83	2410	2.7	0.246
9	25.2 "	399.0	53.2 "	7.30 "	4.44	2790	3.8	0.345
10	4.3 Hg	685.0	10.3 Hg	3.21 Hg	5.79	3640	5.0	0.455
11	6.6 "	898.0	16.6 "	4.07 "	7.33	4610	6.6	0.600
12	8.5 "	1157.0	23.5 "	4.85 "	8.72	5490	7.7	0.700

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{91}

System: Sand-air   Particle size: 30/40 BSS
h_s = 11 cms.   h= 33 cms.   R =3.0   t =24^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.0	CCl_4	47.5	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	4.0	"	63.4	1.3	"	1.14	"	0.68	428	-	-
3	5.8	"	92.0	2.7	"	1.64	"	0.97	610	-	-
4	7.4	"	117.3	4.3	"	2.07	"	1.24	780	-	-
5	9.6	"	152.0	10.5	"	3.24	"	1.95	1228	-	-
6	10.2	"	161.8	27.1	"	5.20	"	3.15	1982	-	-
7	10.6	"	168.0	33.0	"	5.75	"	3.48	2190	-	-
8	18.6	"	295.0	53.0	"	7.28	"	4.42	2780	1.8	0.163
9	3.0	Hg	408.0	8.2	Hg	2.86	Hg	5.14	3235	3.3	0.300
10	3.9	"	530.0	13.1	"	3.62	"	6.52	4105	4.5	0.409
11	6.0	"	816.0	20.1	"	4.48	"	8.06	5080	5.5	0.500
12	8.7	"	1183.0	31.3	"	5.60	"	10.10	6350	6.6	0.600

TABLE-3.B_{92}

System: Sand-air   Particle size: 30/40 BSS
h_s = 11 cms.   h= 38.5 cms.   R= 3.5   T= 23^{o}C

1	2		3	4		5		6	7	8	9
1	3.0	CCl_4	47.5	0.7	CCl_4	0.84	CCl_4	0.49	308	-	-
2	5.0	"	79.2	2.3	"	1.51	"	0.91	572	-	-
3	7.2	"	114.2	4.5	"	2.12	"	1.27	798	-	-
4	10.1	"	160.0	9.5	"	3.08	"	1.85	1164	-	-
5	10.2	"	161.8	17.6	"	4.20	"	2.54	1600	-	-
6	10.3	"	163.0	26.7	"	5.16	"	3.12	1962	-	-
7	10.7	"	169.6	42.2	"	6.50	"	3.95	2485	-	-
8	12.5	"	198.0	55.2	"	7.43	"	4.50	2830	-	-
9	2.2	Hg	299.0	7.5	Hg	2.74	Hg	4.90	3080	1.3	0.118
10	2.6	"	353.5	8.9	"	2.98	"	5.35	3365	1.8	0.163
11	3.7	"	503.0	11.1	"	3.33	"	6.00	3775	4.0	0.364
12	6.4	"	870.0	20.8	"	4.56	"	8.22	5175	5.5	0.500
13	8.7	"	1183.0	31.2	"	5.59	"	10.06	6320	6.3	0.572

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

.B93

System: Sand-air Particle size: 30/40 BSS
h_s = 12 cms. h= 24 cms. R = 2.0 t = 23.5°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.6 CCl_4	57.1	0.5 CCl_4	0.71 CCl_4	0.40	252	-	-
2	5.8 "	92.0	1.3 "	1.14 "	0.68	428	-	-
3	8.0 "	127.0	2.5 "	1.58 "	0.95	598	-	-
4	11.0 "	179.3	5.0 "	2.23 "	1.34	842	-	-
5	10.4 "	164.8	10.8 "	3.28 "	1.97	1240	-	-
6	10.8 "	171.2	20.2 "	4.50 "	2.72	1710	-	-
7	14.6 "	231.5	24.4 "	4.94 "	2.99	1880	-	-
8	19.0 "	301.0	32.0 "	5.65 "	3.43	2160	2.4	0.200
9	26.0 "	412.0	43.9 "	6.62 "	4.01	2525	4.0	0.333
10	3.4 Hg	462.0	6.3 Hg	2.51 Hg	4.53	2850	6.0	0.500
11	4.9 "	666.0	10.5 "	3.24 "	5.80	3650	7.2	0.600
12	8.7 "	1183.0	19.7 "	4.44 "	8.00	5040	9.2	0.765

TABLE-3.B94

System: Sand-air Particle size: 30/40 BSS
h_s= 12 cms. h= 30 cms. R =2.5 t= 24°C

1	2	3	4	5	6	7	8	9
1	2.8 CCl_4	44.4	0.7 CCl_4	0.84 CCl_4	0.49	308	-	-
2	4.8 "	76.1	2.0 "	1.41 "	0.85	535	-	-
3	6.0 "	95.1	3.0 "	1.73 "	1.03	647	-	-
4	7.6 "	120.4	4.6 "	2.14 "	1.28	805	-	-
5	10.0 "	158.5	7.8 "	2.79 "	1.68	1058	-	-
6	10.6 "	168.0	16.4 "	4.05 "	2.45	1542	-	-
7	10.8 "	171.2	24.4 "	4.94 "	2.99	1880	-	-
8	11.0 "	179.3	30.2 "	5.50 "	3.33	2095	-	-
9	17.2 "	272.5	36.3 "	6.02 "	3.64	2290	2.0	0.167
10	2.8 Hg	381.0	5.9 Hg	2.43 Hg	4.37	2750	3.6	0.300
11	3.6 "	490.0	7.8 "	2.79 "	5.01	3160	4.5	0.375
12	5.9 "	803.0	13.5 "	3.67 "	6.60	4150	6.6	0.550
13	8.9 "	1210.0	23.5 "	4.85 "	8.72	5490	7.5	0.625

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{95}

System: Sand-air , Particle size: 30/40 BSS
h_s = 12 cms. h= 36 cms. R=3.0 t= 22°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M²	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m²	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.8 CCl_4	44.4	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	4.8 "	76.1	1.8 "	1.34 "	0.80	504	-	-
3	8.4 "	133.1	5.2 "	2.28 "	1.37	861	-	-
4	10.4 "	164.8	10.4 "	3.22 "	1.95	1225	-	-
5	10.8 "	171.2	25.1 "	5.01 "	3.02	1900	-	-
6	11.1 "	176.0	39.6 "	6.30 "	3.82	2405	-	-
7	1.9 Hg	258.5	5.6 Hg	2.36 "	4.16	2620	-	-
8	2.4 "	326.0	6.2 "	2.49 "	4.46	2808	2.0	0.167
9	2.8 "	381.0	7.9 "	2.81 "	5.06	3188	3.6	0.300
10	3.8 "	517.0	10.6 "	3.26 "	5.88	3700	5.4	0.450
11	5.8 "	789.0	18.7 "	4.32 "	7.80	4910	6.3	0.525
12	7.9 "	1074.0	26.7 "	5.16 "	9.31	5860	7.2	0.600

TABLE-3.B_{96}

System: Sand-air Particle size: 30/40 BSS
h_s = 12 cms. h = 42 cms. R= 3.5 t = 22°C

1	2	3	4	5	6	7	8	9
1	3.2 CCl_4	50.7	0.8 CCl_4	0.89 CCl_4	0.53	333	-	-
2	6.8 "	107.8	3.2 "	1.79 "	1.07	673	-	-
3	9.0 "	142.8	5.4 "	2.32 "	1.39	874	-	-
4	10.6 "	168.0	12.0 "	3.46 "	2.09	1315	-	-
5	10.8 "	171.2	25.4 "	5.04 "	3.04	1912	-	-
6	10.9 "	172.8	35.1 "	5.93 "	3.58	2255	-	-
7	11.2 "	177.5	49.1 "	7.00 "	4.25	2740	-	-
8	2.0 Hg	272.0	7.4 Hg	2.72 Hg	4.90	3080	-	-
9	2.6 "	354.0	8.4 "	2.90 "	5.21	3280	2.0	0.167
10	3.7 "	503.0	11.5 "	3.39 "	6.10	3840	3.6	0.300
11	5.0 "	680.0	16.7 "	4.09 "	7.35	4625	4.8	0.400
12	6.7 "	911.0	22.7 "	4.76 "	8.60	5410	5.4	0.450
13	9.2 "	1252.0	32.4 "	5.69 "	10.24	6440	6.6	0.550

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{97}

System: Magnesite-air Particle size: 30/40 BSSS
h_s = 9 cms. h= 18 cms. R = 2.0 t = 23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{1/2}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.3 CCl_4	52.3	0.9 CCl_4	0.95 CCl_4	0.55	346	-	-
2	6.3 "	99.9	3.5 "	1.87 "	1.12	705	-	-
3	7.7 "	122.1	5.2 "	2.28 "	1.37	861	-	-
4	8.1 "	128.5	12.7 "	3.56 "	2.15	1352	-	-
5	8.3 "	131.6	18.4 "	4.29 "	2.59	1630	-	-
6	8.4 "	133.1	24.7 "	4.97 "	3.00	1887	-	-
7	9.9 "	157.0	32.8 "	5.72 "	3.46	2180	-	-
8	13.9 "	220.4	40.7 "	6.38 "	3.87	2438	1.0	0.111
9	17.9 "	284.0	48.6 "	6.97 "	4.23	2660	2.0	0.222
10	2.4 Hg	326.5	6.4 Hg	2.53 Hg	4.55	2860	3.0	0.333
11	3.8 "	517.0	9.2 "	3.03 "	5.43	3420	4.5	0.500
12	7.0 "	952.0	18.4 "	4.29 "	7.70	4850	6.0	0.666
13	12.9 "	1755.0	33.3 "	5.77 "	10.40	6540	7.2	0.800

TABLE-3.B_{98}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 9 cms. h= 22.5 cms. R = 2.5 t = 24°C

1	2	3	4	5	6	7	8	9
1	2.5 CCl_4	39.6	0.7 CCl_4	0.84 CCl_4	0.50	315	-	-
2	3.9 "	61.8	2.0 "	1.41 "	0.85	535	-	-
3	5.7 "	90.4	4.1 "	2.02 "	1.21	760	-	-
4	8.5 "	134.8	7.3 "	2.70 "	1.63	1025	-	-
5	7.9 "	123.7	12.0 "	3.46 "	2.09	1315	-	-
6	8.5 "	134.8	26.2 "	5.11 "	3.10	1950	-	-
7	9.9 "	157.0	37.7 "	6.14 "	3.72	2340	-	-
8	13.1 "	207.5	47.9 "	6.92 "	4.20	2640	1.0	0.111
9	2.9 Hg	394.0	8.3 Hg	2.88 Hg	5.18	3260	2.7	0.300
10	4.0 "	544.0	11.4 "	3.38 "	6.19	3892	3.6	0.400
11	5.2 "	708.0	14.7 "	3.83 "	6.90	4350	4.5	0.500
12	10.2 "	1388.0	28.5 "	5.33 "	9.60	6050	6.0	0.666

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{99}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 9 cms. h= 27 cms. R= 3.0 t = 25°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	2.6 CCl_4	41.2	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	3.8 "	60.2	2.2 "	1.48 "	0.89	560	-	-
3	7.0 "	111.0	6.6 "	2.57 "	1.55	975	-	-
4	8.0 "	127.0	14.6 "	3.82 "	2.30	1448	-	-
5	8.4 "	133.1	26.8 "	5.17 "	3.13	1970	-	-
6	8.8 "	139.6	39.7 "	6.30 "	3.82	2405	-	-
7	9.6 "	152.2	51.3 "	7.16 "	4.35	2735	-	-
8	1.7 Hg	231.0	7.4 Hg	2.72 Hg	4.90	3080	1.0	0.111
9	2.9 "	394.0	9.2 "	3.03 "	5.43	3420	2.7	0.300
10	4.8 "	653.0	18.2 "	4.26 "	7.70	4850	3.6	0.400
11	6.8 "	925.0	22.9 "	4.78 "	8.60	5410	4.2	0.466
12	9.8 "	1333.0	34.3 "	5.85 "	10.52	6610	5.0	0.555

TABLE-3.B_{100}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 9 cms. h =31.5 cms. R =3.5 t = 26°C

1	2	3	4	5	6	7	8	9
1	2.6 CCl_4	41.2	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	4.1 "	65.0	2.6 "	1.61 "	0.94	591	-	-
3	6.3 "	99.9	5.7 "	2.38 "	1.43	899	-	-
4	7.9 "	125.3	8.1 "	2.85 "	1.72	1080	-	-
5	8.1 "	128.4	16.7 "	4.09 "	2.46	1550	-	-
6	8.3 "	131.6	23.9 "	4.89 "	2.95	1857	-	-
7	8.7 "	138.0	33.5 "	5.79 "	3.50	2200	-	-
8	9.1 "	144.2	49.6 "	7.05 "	4.28	2690	-	-
9	1.1 Hg	149.7	7.0 Hg	2.64 "	4.77	3000	-	-
10	1.9 "	258.5	10.6 "	3.26 "	5.89	3700	1.0	0.111
11	2.9 "	394.0	13.2 "	3.63 "	6.53	4105	2.0	0.222
12	5.5 "	748.0	21.0 "	4.58 "	8.25	5190	3.6	0.400
13	8.5 "	1156.0	32.3 "	5.68 "	10.23	6440	4.8	0.534

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{101}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 10 cms. h= 20 cms. R =2.0 t = 25°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	3.9	CCl_4	61.8	1.0	CCl_4	1.00	CCl_4	0.60	377	-	-
2	4.6	"	72.9	1.8	"	1.34	"	0.80	504	-	-
3	7.3	"	115.8	4.4	"	2.10	"	1.26	792	-	-
4	9.5	"	150.8	7.6	"	2.76	"	1.66	1045	-	-
5	8.9	"	141.0	10.5	"	3.24	"	1.95	1226	-	-
6	9.3	"	147.4	22.9	"	4.79	"	2.90	1825	-	-
7	10.3	"	163.0	29.1	"	5.40	"	3.26	2050	-	-
8	12.7	"	201.0	33.5	"	5.79	"	3.50	2200	1.0	0.10
9	22.5	"	356.5	51.2	"	7.16	"	4.35	2740	3.0	0.30
10	3.4	Hg	462.0	7.2	Hg	2.68	Hg	4.82	3035	4.5	0.45
11	4.8	"	652.0	10.0	"	3.16	"	5.70	3585	5.5	0.55
12	8.4	"	1142.0	19.0	"	4.36	"	7.85	4940	7.0	0.70

TABLE-3.B_{102}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 10 cms. h = 25 cms. R= 2.5 t= 25°C

1	2		3	4		5		6	7	8	9
1	2.9	CCl_4	46.0	1.2	CCl_4	1.09	CCl_4	0.65	409	-	-
2	3.9	"	61.8	2.0	"	1.41	"	0.85	535	-	-
3	5.9	"	93.5	4.6	"	2.14	"	1.28	805	-	-
4	8.3	"	131.5	8.0	"	2.82	"	1.70	1070	-	-
5	8.9	"	141.0	13.0	"	3.60	"	2.17	1365	-	-
6	9.3	"	147.4	24.9	"	4.99	"	3.00	1887	-	-
7	10.1	"	160.0	32.5	"	5.70	"	3.45	2170	-	-
8	16.3	"	258.0	47.0	"	6.85	"	4.15	2610	1.0	0.10
9	2.5	Hg	340.0	6.9	Hg	2.62	Hg	4.72	2970	2.2	0.22
10	3.4	"	462.0	9.4	"	3.06	"	5.51	3470	3.5	0.35
11	5.5	"	748.0	13.9	"	3.73	"	6.71	4225	5.0	0.50
12	8.2	"	1115.0	21.6	"	4.65	"	8.40	5290	6.0	0.60

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS-VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{103}

System: Magnesite-air   Particle size: 30/40 BSS
h_s = 10 cms.   h = 30 cms.   R =3.0   t = 26°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	2.5	CCl_4	40.0	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	3.7	"	59.0	1.6	"	1.26	"	0.75	472	-	-
3	5.4	"	85.6	3.3	"	1.81	"	1.09	685	-	-
4	6.8	"	107.8	4.9	"	2.21	"	1.33	835	-	-
5	9.0	"	142.8	14.7	"	3.83	"	2.31	1452	-	-
6	9.2	"	146.0	21.0	"	4.58	"	2.76	1672	-	-
7	9.6	"	152.2	34.4	"	5.86	"	3.55	2232	-	-
8	9.8	"	155.4	46.0	"	6.78	"	4.11	2588	-	-
9	2.2	Hg	299.0	7.0	Hg	2.64	"	4.76	3000	1.00	0.100
10	3.2	"	435.0	8.9	"	2.98	"	5.35	3365	2.50	0.250
11	5.4	"	735.0	17.3	"	4.16	"	7.50	4715	4.25	0.425
12	8.0	"	1088.0	29.7	"	5.45	"	9.80	6160	5.00	0.500

TABLE-3.B_{104}

System: Magnesite-air   Particle size: 30/40 BSS
h_s = 10 cms.   h= 35 cms.   R =3.5   t = 26°C

1	2		3	4		5		6	7	8	9
1	2.3	CCl_4	36.4	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	3.7	"	58.6	2.0	"	1.41	"	0.85	535	-	-
3	5.8	"	91.9	4.2	"	2.05	"	1.23	774	-	-
4	7.9	"	125.2	7.6	"	2.76	"	1.66	1045	-	-
5	9.2	"	146.0	21.3	"	4.61	"	2.79	1755	-	-
6	9.6	"	152.2	30.9	"	5.55	"	3.36	2115	-	-
7	10.0	"	158.5	48.0	"	6.93	"	4.20	2640	-	-
8	1.6	Hg	217.5	7.7	Hg	2.78	Hg	5.00	3145	-	-
9	2.4	"	326.5	9.5	"	3.08	"	5.53	3480	1.30	0.130
10	3.0	"	408.0	12.1	"	3.48	"	6.25	3930	2.00	0.200
11	4.2	"	571.0	15.4	"	3.92	"	7.14	4490	3.00	0.300
12	8.5	"	1157.0	27.5	"	5.25	"	9.46	5950	4.25	0.425
13	10.4	"	1415.0	36.3	"	6.02	"	10.83	6810	4.75	0.475

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS-VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{105}

System: Magnesite-air   Particle size: 30/40 BSS
h_s = 11 cms.   h = 22 cms.   R = 2.0   t= 22°C

	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
	2		3	4		5		6	7	8	9
1	2.9	CCl_4	45.9	0.6	CCl_4	0.78	CCl_4	0.45	283	-	-
2	4.7	"	74.4	1.4	"	1.18	"	0.70	441	-	-
3	8.9	"	141.0	5.4	"	2.33	"	1.40	880	-	-
4	9.5	"	150.5	11.0	"	3.32	"	2.00	1258	-	-
5	9.7	"	153.8	17.7	"	4.21	"	2.55	1602	-	-
6	11.9	"	188.5	29.5	"	5.43	"	3.28	2060	-	-
7	14.5	"	230.0	33.7	"	5.80	"	3.51	2205	1.0	0.091
8	17.9	"	284.0	39.9	"	6.31	"	3.83	2408	2.0	0.182
9	2.9	Hg	394.0	5.7	Hg	2.38	Hg	4.29	2700	3.5	0.318
10	4.1	"	557.0	8.6	"	2.93	"	5.25	3300	5.0	0.455
11	4.9	"	666.0	9.8	"	3.13	"	5.62	3540	6.0	0.546
12	8.5	"	1158.0	18.5	"	4.30	"	7.75	4870	7.5	0.681

TABLE-3.B_{106}

System: Magnesite-air   Particle size: 30/40 BSS
h_s = 11 cms.   h = 27.5 cms.   R = 2.5   t = 23°C

1	2		3	4		5		6	7	8	9
1	2.7	CCl_4	42.8	0.9	CCl_4	0.95	CCl_4	0.55	346	-	-
2	3.7	"	58.6	1.9	"	1.38	"	0.82	515	-	-
3	5.7	"	90.4	3.8	"	1.95	"	1.17	735	-	-
4	7.7	"	122.0	6.6	"	2.57	"	1.55	974	-	-
5	9.7	"	153.8	16.6	"	4.07	"	2.46	1548	-	-
6	10.1	"	160.0	27.6	"	5.25	"	3.17	1992	-	-
7	10.2	"	161.7	34.1	"	5.84	"	3.54	2225	-	-
8	11.9	"	188.6	41.2	"	6.41	"	3.90	2450	-	-
9	17.9	"	283.5	48.9	"	6.99	"	4.24	2665	1.1	0.100
10	2.9	Hg	394.0	7.0	Hg	2.65	Hg	4.75	2985	2.5	0.227
11	4.3	"	585.0	9.9	"	3.15	"	5.65	3555	4.0	0.364
12	6.4	"	870.0	13.5	"	3.68	"	6.60	4150	5.5	0.500
13	8.8	"	1198.0	23.2	"	4.82	"	8.68	5460	6.6	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS-VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{107}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 11 cms h = 33.0 cms. R = 3.0 t = 23.5^{o}C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$		W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	2.5	CCl_4	39.6	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	3.7	"	58.6	1.8	"	1.34	"	0.80	504	-	-
3	5.4	"	85.6	3.8	"	1.95	"	1.17	735	-	-
4	7.4	"	107.2	6.7	"	2.58	"	1.55	974	-	-
5	9.8	"	155.3	16.0	"	4.00	"	2.41	1516	-	-
6	10.0	"	158.5	24.6	"	4.96	"	3.00	1888	-	-
7	10.2	"	161.7	33.1	"	5.75	"	3.48	2190	-	-
8	10.4	"	164.8	47.8	"	6.91	"	4.20	2640	-	-
9	1.9	Hg	258.0	6.6	Hg	2.56	Hg	4.62	2906	-	-
10	2.5	"	340.0	8.5	"	2.91	"	5.23	3286	1.5	0.136
11	3.6	"	489.0	10.3	"	3.20	"	5.80	3650	3.0	0.273
12	5.1	"	694.0	14.9	"	3.86	"	6.97	4385	4.0	0.364
13	8.1	"	1101.0	27.2	"	5.21	"	9.40	5910	5.5	0.500

TABLE -3.B_{108}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 11 cms. h = 38.5 cms. R= 3.5 t = 25^{o}C

1	2		3	4		5		6	7	8	9
1	2.7	CCl_4	42.7	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	4.5	"	71.3	2.4	"	1.55	"	0.93	585	-	-
3	6.2	"	98.4	4.5	"	2.12	"	1.27	798	-	-
4	8.0	"	126.8	7.0	"	2.64	"	1.60	1006	-	-
5	9.8	"	155.3	15.6	"	3.95	"	2.39	1502	-	-
6	10.3	"	163.2	38.0	"	6.16	"	3.74	2350	-	-
7	10.5	"	166.3	48.3	"	6.95	"	4.23	2660	-	-
8	1.5	Hg	204.0	8.2	Hg	2.86	Hg	5.16	3250	-	-
9	2.3	"	312.5	10.3	"	3.21	"	5.80	3650	1.1	0.100
10	3.1	"	421.0	12.0	"	3.46	"	6.22	3915	2.5	0.227
11	4.4	"	599.0	16.0	"	4.00	"	7.20	4525	3.5	0.318
12	9.4	"	1280.0	35.3	"	5.94	"	10.70	6740	5.5	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{109}

System: Magnesite-air   Particle size: 30/40 BSS
h_s = 12 cms.   h = 24 cms.   R= 2.0   t = 23.5°C

Sl. No.	ΔH_1 Cms.		ΔP Kg/M^2	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{1/2}$		W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2		3	4		5		6	7	8	9
1	4.0	CCl_4	63.4	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	6.4	"	101.4	2.0	"	1.41	"	0.85	535	-	-
3	8.2	"	130.0	3.0	"	1.73	"	1.03	647	-	-
4	10.4	"	164.8	5.3	"	2.30	"	1.39	875	-	-
5	10.6	"	168.0	11.9	"	3.45	"	2.08	1310	-	-
6	11.2	"	177.5	21.7	"	4.66	"	2.82	1775	-	-
7	11.8	"	187.0	23.7	"	4.87	"	2.95	1857	-	-
8	15.8	"	250.0	32.4	"	5.69	"	3.44	2160	1.2	0.100
9	17.8	"	282.0	38.9	"	6.23	"	3.77	2370	2.4	0.200
10	24.6	"	390.0	45.6	"	6.75	"	4.10	2580	4.0	0.333
11	28.2	"	447.0	51.4	"	7.17	"	4.35	2740	5.0	0.416
12	4.3	Hg	585.0	7.3	Hg	2.70	Hg	4.85	3050	6.0	0.500
13	7.9	"	107.5	15.6	"	3.94	"	7.10	4460	8.0	0.666

TABLE-3.B_{110}

System : Magnesite-air   Particle size: 30/40 BSS
h_s = 12 cms.   h = 30 cms.   R = 2.5   t = 24°C

1	2		3	4		5		6	7	8	9
1	3.0	CCl_4	47.5	0.8	CCl_4	0.89	CCl_4	0.53	333	-	-
2	6.8	"	107.8	3.4	"	1.84	"	1.10	691	-	-
3	8.8	"	139.5	5.8	"	2.40	"	1.45	912	-	-
4	10.8	"	171.0	12.7	"	3.56	"	2.15	1352	-	-
5	11.0	"	174.2	23.1	"	4.81	"	2.91	1830	-	-
6	11.2	"	177.5	27.9	"	5.28	"	3.19	2015	-	-
7	11.4	"	180.8	31.4	"	5.60	"	3.39	2135	-	-
8	13.8	"	218.5	35.0	"	5.91	"	3.59	2260	-	-
9	16.2	"	256.5	40.9	"	6.40	"	3.88	2440	1.2	0.100
10	20.2	"	320.0	45.8	"	6.76	"	4.10	2580	3.0	0.250
11	3.8	Hg	516.0	8.4	Hg	2.90	Hg	5.20	3270	4.5	0.375
12	6.4	"	870.0	14.9	"	3.86	"	6.94	4360	6.0	0.500
13	9.2	"	1251.0	23.2	"	4.82	"	8.66	5450	7.2	0.600

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

TABLE-3.B_{111}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 12 cms. h = 36 cms. R =3.0 t = 25°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	3.0 CCl_4	47.5	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	6.2 "	98.2	4.0 "	2.00 "	1.20	755	-	-
3	7.8 "	123.5	5.9 "	2.43 "	1.46	919	-	-
4	11.4 "	180.8	11.4 "	3.37 "	2.04	1285	-	-
5	11.0 "	174.2	21.9 "	4.67 "	2.82	1775	-	-
6	11.2 "	177.5	30.0 "	5.47 "	3.31	2080	-	-
7	11.7 "	185.2	38.6 "	6.21 "	3.76	2365	-	-
8	14.1 "	223.5	50.7 "	7.11 "	4.32	2720	-	-
9	2.4 Hg	326.0	7.1 Hg	2.66 Hg	4.80	3020	1.5	0.125
10	3.6 "	489.0	8.6 "	2.93 "	5.26	3310	3.0	0.250
11	4.4 "	598.0	11.0 "	3.32 "	5.96	3750	4.0	0.333
12	6.2 "	843.0	15.8 "	3.97 "	7.15	4500	5.4	0.450
13	8.5 "	1157.0	19.6 "	4.42 "	7.97	5010	6.6	0.550

TABLE-3.B_{112}

System: Magnesite-air Particle size: 30/40 BSS
h_s = 12 cms. h =42 cms. R =3.5 t= 26 °C

1	2	3	4	5	6	7	8	9
1	3.6 CCl_4	57.0	1.3 CCl_4	1.14 CCl_4	0.68	428	-	-
2	7.0 "	111.0	4.7 "	2.16 "	1.31	825	-	-
3	9.5 "	150.5	8.2 "	2.86 "	1.73	1090	-	-
4	10.9 "	172.8	14.9 "	3.86 "	2.34	1472	-	-
5	11.3 "	179.0	29.4 "	5.41 "	3.28	2060	-	-
6	11.7 "	185.3	40.8 "	6.39 "	3.87	2435	-	-
7	1.4 Hg	190.2	6.2 Hg	2.49 "	4.47	2810	-	-
8	1.6 "	217.5	7.7 "	2.77 "	5.00	3140	-	-
9	2.4 "	326.0	8.6 "	2.93 "	5.26	3310	1.5	0.125
10	3.6 "	489.0	10.3 "	3.21 "	5.80	3650	3.0	0.250
11	4.7 "	639.0	13.6 "	3.68 "	6.61	4140	4.0	0.333
12	8.1 "	1101.0	24.5 "	4.95 "	8.90	5600	5.4	0.450

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{113}

System: Mustard seed-air   Particles size: 14/20 BSS
h_s = 9 cms.   h = 18 cms.   R = 2.0   t = 22.5°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M²	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m²	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	0.90 CCl_4	14.3	0.9 CCl_4	0.95 CCl_4	0.55	346	-	-
2	1.30 "	20.6	1.9 "	1.38 "	0.82	516	-	-
3	2.60 "	41.2	6.1 "	2.47 "	1.49	937	-	-
4	3.60 "	57.0	10.2 "	3.19 "	1.93	1214	-	-
5	3.90 "	61.8	19.6 "	4.42 "	2.67	1680	-	-
6	4.00 "	63.4	26.9 "	5.18 "	3.13	1970	-	-
7	4.20 "	66.5	40.1 "	6.34 "	3.84	2420	-	-
8	5.00 "	79.2	46.2 "	6.80 "	4.12	2595	-	-
9	7.00 "	111.0	6.7 Hg	2.58 Hg	4.64	2920	1.5	0.166
10	11.20 "	177.5	10.4 "	3.22 "	5.80	3650	3.0	0.333
11	19.60 "	310.5	19.4 "	4.40 "	7.90	4960	4.5	0.500
12	31.00 "	491.0	29.0 "	5.39 "	9.70	6100	5.4	0.600

TABLE-3.B_{114}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 9 cms.   h = 22.5 cms.   R =2.5   t = 23°C

1	2	3	4	5	6	7	8	9
1	0.90 CCl_4	14.3	1.2 CCl_4	1.10 CCl_4	0.65	409	-	-
2	1.30 "	20.6	2.4 "	1.55 "	0.92	579	-	-
3	1.85 "	29.3	4.0 "	2.00 "	1.20	755	-	-
4	2.65 "	42.0	6.9 "	2.62 "	1.58	994	-	-
5	3.55 "	56.2	11.5 "	3.39 "	2.04	1284	-	-
6	3.85 "	61.0	22.1 "	4.70 "	2.85	1793	-	-
7	3.95 "	62.6	27.7 "	5.26 "	3.18	2000	-	-
8	4.25 "	67.4	47.1 "	6.86 "	4.16	2620	-	-
9	5.25 "	83.1	6.5 Hg	2.55 Hg	4.60	2895	-	-
10	7.05 "	111.8	8.0 "	2.83 "	5.08	3195	1.2	0.133
11	9.80 "	155.3	13.2 "	3.63 "	6.52	4100	2.5	0.278
12	16.30 "	258.0	19.6 "	4.43 "	7.96	5010	3.6	0.400
13	24.60 "	390.0	29.3 "	5.41 "	9.75	6130	4.5	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{115}

System: Mustard seed-air   Particles size: 14/20 BSS
h_s = 9 cms.   h = 27 cms.   R = 3.0   t = 23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	0.9 CCl_4	14.3	1.5 CCl_4	1.23 CCl_4	0.73	459	-	-
2	1.5 "	23.8	3.5 "	1.87 "	1.12	705	-	-
3	2.6 "	41.2	8.6 "	2.93 "	1.77	1113	-	-
4	3.4 "	53.9	13.9 "	3.73 "	2.25	1415	-	-
5	3.8 "	60.2	22.3 "	4.72 "	2.85	1791	-	-
6	4.0 "	63.3	30.4 "	5.51 "	3.34	2100	-	-
7	4.2 "	66.6	51.0 "	7.15 "	4.35	2735	-	-
8	4.4 "	69.7	8.0 Hg	2.83 Hg	5.10	3206	-	-
9	6.0 "	95.0	10.2 "	3.19 "	5.75	3615	-	-
10	9.8 "	155.3	15.4 "	3.92 "	7.04	4425	1.2	0.133
11	15.8 "	250.0	22.5 "	4.75 "	8.55	5375	2.0	0.222
12	21.6 "	342.0	28.7 "	5.36 "	9.65	6060	3.0	0.333
13	30.5 "	484.0	38.6 "	6.22 "	11.20	7050	4.8	0.534

TABLE-3.B_{116}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 9 cms.   h = 31.5 cms.   R = 3.5   t = 24°C.

1	2	3	4	5	6	7	8	9
1	0.9 CCl_4	14.3	1.4 CCl_4	1.18 CCl_4	0.70	440	-	-
2	1.5 "	22.8	3.9 "	1.97 "	1.19	749	-	-
3	2.1 "	33.3	6.6 "	2.57 "	1.55	975	-	-
4	2.7 "	42.8	10.1 "	3.18 "	1.92	1208	-	-
5	3.7 "	58.6	19.8 "	4.45 "	2.70	1700	-	-
6	4.0 "	63.4	29.9 "	5.47 "	3.31	2080	-	-
7	4.3 "	68.1	54.3 "	7.37 "	4.47	2810	-	-
8	4.5 "	71.3	12.2 Hg	3.49 Hg	6.29	3952	-	-
9	5.7 "	90.4	15.4 "	3.92 "	7.05	4430	-	-
10	11.8 "	187.0	20.5 "	4.53 "	8.14	5110	1.2	0.133
11	18.7 "	296.4	27.4 "	5.24 "	9.40	5910	2.5	0.278
12	26.3 "	416.5	37.7 "	6.15 "	11.06	6960	3.3	0.367

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{117}

System: Mustard seed-air h_s = 10 cms. h = 20 cms. Particle size: 14/20 BSS R= 2.0 t = 24°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.0 CCl_4	15.8	0.8 CCl_4	0.89 CCl_4	0.53	333	-	-
2	1.6 "	25.4	1.8 "	1.34 "	0.80	504	-	-
3	2.4 "	38.0	3.6 "	1.90 "	1.15	724	-	-
4	3.2 "	50.6	6.4 "	2.53 "	1.53	963	-	-
5	4.4 "	69.7	11.9 "	3.45 "	2.08	1310	-	-
6	4.5 "	71.3	24.5 "	4.95 "	3.00	1887	-	-
7	4.6 "	72.9	32.7 "	5.72 "	3.47	2180	-	-
8	5.6 "	88.7	46.7 "	6.84 "	4.15	2610	-	-
9	6.4 "	101.5	52.8 "	7.26 "	4.41	2775	1.0	0.100
10	8.8 "	139.5	7.7 Hg	2.78 Hg	5.00	3145	2.5	0.250
11	12.5 "	198.0	10.8 "	3.28 "	5.90	3710	4.0	0.400
12	19.8 "	314.0	16.1 "	4.01 "	7.22	4540	5.0	0.500
13	29.6 "	469.0	24.6 "	4.96 "	8.92	5610	6.0	0.600

TABLE-3.B_{118}

System: Mustard seed-air h_s =10 cms. h= 25 cms. Particles size: 14/20 BSS R=2.5 t = 25°C

1	2	3	4	5	6	7	8	9
1	1.0 CCl_4	15.8	1.3 CCl_4	1.14 CCl_4	0.68	427	-	-
2	1.6 "	25.4	3.1 "	1.76 "	1.06	667	-	-
3	2.2 "	34.9	5.0 "	2.24 "	1.35	850	-	-
4	3.2 "	50.6	9.2 "	3.03 "	1.83	1150	-	-
5	4.4 "	69.7	24.1 "	4.91 "	2.97	1870	-	-
6	4.6 "	72.9	34.4 "	5.86 "	3.55	2232	-	-
7	4.8 "	76.0	44.5 "	6.67 "	4.04	2540	-	-
8	6.2 "	98.2	7.9 Hg	2.81 Hg	5.05	3175	-	-
9	7.8 "	123.8	9.8 "	3.13 "	5.62	3540	1.0	0.100
10	9.6 "	152.2	10.7 "	3.27 "	5.90	3710	2.0	0.200
11	13.6 "	215.5	14.8 "	3.85 "	6.93	4350	3.3	0.330
12	25.1 "	398.0	22.7 "	4.76 "	8.59	5400	5.4	0.540

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{119}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 10 cms   h = 30 cms.   R = 3.0   t = 25.5°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	0.9 CCl_4	14.3	1.2 CCl_4	1.10 CCl_4	0.65	409	-	-
2	1.4 "	22.2	2.8 "	1.67 "	1.00	629	-	-
3	2.2 "	34.8	5.8 "	2.41 "	1.45	913	-	-
4	2.8 "	44.4	9.2 "	3.03 "	1.83	1150	-	-
5	4.1 "	65.0	16.2 "	4.03 "	2.43	1530	-	-
6	4.7 "	74.5	32.2 "	5.68 "	3.44	2164	-	-
7	4.9 "	77.6	55.6 "	7.45 "	4.52	2844	-	-
8	5.0 "	79.2	8.9 Hg	2.98 Hg	5.35	3360	-	-
9	6.9 "	109.3	12.2 "	3.49 "	6.30	3960	-	-
10	8.5 "	134.8	13.1 "	3.62 "	6.52	4100	1.0	0.10
11	11.9 "	188.6	17.1 "	4.14 "	7.45	4690	2.0	0.20
12	16.9 "	268.0	21.1 "	4.60 "	8.30	5215	3.0	0.30
13	23.1 "	366.0	27.8 "	5.27 "	9.50	5970	4.0	0.40

TABLE-3.B_{120}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 10 cms.   h =35 cms.   R = 3.5   t= 26°C

1	2	3	4	5	6	7	8	9
1	0.8 CCl_4	12.7	1.2 CCl_4	1.10 CCl_4	0.65	409	-	-
2	1.4 "	22.2	3.2 "	1.79 "	1.07	672	-	-
3	2.1 "	33.3	6.1 "	2.47 "	1.48	931	-	-
4	2.9 "	46.0	9.7 "	3.11 "	1.88	1182	-	-
5	4.4 "	69.7	27.9 "	5.28 "	3.20	2012	-	-
6	4.6 "	72.9	36.8 "	6.06 "	3.67	2306	-	-
7	4.7 "	74.5	54.3 "	7.37 "	4.48	2820	-	-
8	4.9 "	77.6	10.5 Hg	2.24 Hg	5.35	3360	-	-
9	7.1 "	102.6	16.8 "	4.10 "	7.40	4650	-	-
10	8.1 "	128.3	20.6 "	4.55 "	8.20	5155	1.0	0.10
11	18.1 "	286.8	27.1 "	5.21 "	9.40	5910	2.8	0.28
12	20.9 "	331.5	32.3 "	5.69 "	10.25	6450	3.5	0.35

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{121}

System: Mustard seed-air Particles size:14/20 BSS
h_s = 11 cms. h = 22 cms. R = 2.0 t = 22.5°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.1 CCl_4	17.4	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	1.9 "	30.1	2.4 "	1.55 "	0.93	585	-	-
3	2.9 "	46.0	4.9 "	2.21 "	1.34	843	-	-
4	4.3 "	68.1	9.3 "	3.05 "	1.84	1158	-	-
5	4.9 "	77.6	20.1 "	4.49 "	2.70	1700	-	-
6	5.1 "	80.9	30.9 "	5.55 "	3.37	2120	-	-
7	6.1 "	96.6	43.8 "	6.62 "	4.01	2520	-	-
8	7.1 "	102.6	49.6 "	7.05 "	4.28	2690	1.1	0.100
9	10.9 "	172.8	6.9 Hg	2.53 Hg	4.55	2860	3.0	0.272
10	13.3 "	210.5	9.6 "	3.10 "	5.60	3520	4.0	0.364
11	19.1 "	302.5	13.9 "	3.73 "	6.70	4210	5.5	0.500
12	32.7 "	508.5	24.8 "	4.98 "	8.96	5640	7.0	0.636

TABLE-3.B_{122}

System: Mustard seed-air Particle size: 14/20 BSS
h_s = 11 cms. h= 27.5 cms R =2.5 t= 23°C

1	2	3	4	5	6	7	8	9
1	0.9 CCl_4	14.3	1.0 CCl_4	1.00 CCl_4	0.60	377	-	-
2	1.7 "	27.0	3.0 "	1.73 "	1.03	647	-	-
3	3.3 "	52.3	9.3 "	3.05 "	1.84	1158	-	-
4	4.9 "	77.6	25.1 "	5.01 "	3.03	1906	-	-
5	5.0 "	79.2	31.1 "	5.58 "	3.37	2120	-	-
6	5.1 "	80.9	38.5 "	6.20 "	3.75	2360	-	-
7	5.3 "	84.0	50.0 "	7.07 "	4.29	2700	-	-
8	5.9 "	93.5	6.5 Hg	2.55 Hg	4.60	2895	-	-
9	7.5 "	119.0	8.2 "	2.86 "	5.16	3245	1.1	0.100
10	9.7 "	153.8	10.0 "	3.16 "	5.70	3580	3.0	0.272
11	17.7 "	280.5	17.6 "	4.20 "	7.55	4750	4.0	0.364
12	30.9 "	490.0	27.3 "	5.22 "	9.40	5910	6.2	0.564

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION (BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{123}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 11 cms.   h= 33.0 cms.   R=3.0   t = 24°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{1/2}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.2 CCl_4	19.0	2.2 CCl_4	1.48 CCl_4	0.88	554	-	-
2	1.8 "	28.5	4.6 "	2.14 "	1.29	811	-	-
3	2.4 "	38.0	7.5 "	2.74 "	1.65	1038	-	-
4	4.4 "	69.7	19.8 "	4.45 "	2.70	1700	-	-
5	5.0 "	79.2	34.8 "	5.90 "	3.58	2250	-	-
6	5.2 "	82.4	47.8 "	6.91 "	4.20	2640	-	-
7	5.3 "	84.0	8.2 Hg	2.86 Hg	5.16	3245	-	-
8	6.1 "	95.9	11.3 "	3.36 "	6.05	3805	-	-
9	9.9 "	157.2	14.7 "	3.84 "	6.90	4340	1.1	0.100
10	14.9 "	236.0	17.2 "	4.15 "	7.50	4710	2.6	0.236
11	18.0 "	285.0	20.2 "	4.50 "	8.10	5095	3.6	0.327
12	30.7 "	486.0	32.0 "	5.65 "	10.20	6415	5.0	0.455

TABLE-3.B_{124}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 11 cms.   h = 38.5 cms.   R= 3.5   t = 25°C

1	2	3	4	5	6	7	8	9
1	1.3 CCl_4	20.6	2.2 CCl_4	1.48 CCl_4	0.88	554	-	-
2	2.2 "	34.8	5.5 "	2.34 "	1.40	881	-	-
3	3.0 "	47.5	9.0 "	3.00 "	1.80	1131	-	-
4	4.3 "	68.1	16.0 "	4.00 "	2.41	1516	-	-
5	4.7 "	74.5	21.3 "	4.61 "	2.79	1755	-	-
6	4.9 "	77.6	30.9 "	5.55 "	3.37	2120	-	-
7	5.3 "	84.0	52.5 "	7.25 "	4.40	2765	-	-
8	5.5 "	87.1	11.3 Hg	3.36 Hg	6.05	3805	-	-
9	5.9 "	93.5	16.3 "	4.04 "	7.25	4560	-	-
10	11.7 "	185.2	18.4 "	4.29 "	7.70	4840	1.2	0.109
11	19.3 "	305.5	24.9 "	4.99 "	8.98	5650	2.5	0.227
12	32.3 "	511.5	33.8 "	5.81 "	10.48	6590	4.4	0.400
13	44.4 "	704.0	42.3 "	6.50 "	11.70	7360	5.5	0.500

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B$_{125}$

System: Mustard seed-air Particle size: 14/20 BSS
h_s = 12 cms. h = 24 cms. R= 2.0 t = 23°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.5 CCl_4	23.8	1.6 CCl_4	1.2 CCl_4	0.75	471	-	-
2	2.5 "	39.6	3.8 "	1.95 "	1.17	735	-	-
3	4.6 "	72.9	11.7 "	3.42 "	2.06	1295	-	-
4	5.1 "	80.9	19.3 "	4.40 "	2.65	1667	-	-
5	5.3 "	84.0	31.4 "	5.60 "	3.40	2140	-	-
6	6.0 "	95.1	44.8 "	6.70 "	4.06	2555	-	-
7	7.4 "	107.2	51.0 "	7.1 "	4.34	2730	1.2	0.100
8	9.8 "	155.3	7.7 Hg	2.78 Hg	5.00	3145	2.4	0.200
9	14.4 "	228.0	10.4 "	3.22 "	5.80	3645	4.0	0.333
10	19.2 "	304.4	13.5 "	3.68 "	6.61	4160	5.4	0.450
11	29.6 "	469.0	21.9 "	4.68 "	8.42	5300	6.6	0.550
12	49.2 "	780.0	34.9 "	5.90 "	10.61	6685	8.0	0.666

TABLE-3.B$_{126}$

System: Mustard seed-air Particle size: 14/20 BSS
h_s = 12 cms. h = 30 cms. R= 2.5 t= 24°C

1	2	3	4	5	6	7	8	9
1	1.6 CCl_4	25.3	1.9 CCl_4	1.38 CCl_4	0.82	515	-	-
2	2.4 "	38.0	3.9 "	1.97 "	1.19	749	-	-
3	3.0 "	47.5	6.0 "	2.45 "	1.47	925	-	-
4	4.8 "	76.1	12.9 "	3.59 "	2.16	1360	-	-
5	5.2 "	82.4	25.6 "	5.06 "	3.06	1925	-	-
6	5.6 "	88.7	40.5 "	6.37 "	3.86	2425	-	-
7	5.7 "	90.4	52.6 "	7.25 "	4.40	2765	-	-
8	7.4 "	107.2	9.4 Hg	3.06 Hg	5.51	3470	0.6	0.050
9	11.4 "	180.8	11.9 "	3.45 "	6.20	3900	2.0	0.166
10	15.2 "	240.6	14.7 "	3.84 "	6.90	4340	3.0	0.250
11	19.6 "	310.5	16.2 "	4.03 "	7.25	4560	4.0	0.333
12	25.2 "	399.5	20.6 "	4.54 "	8.16	5135	5.0	0.416
13	47.1 "	746.0	37.4 "	6.11 "	11.01	6940	7.0	0.583

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{127}

System: Mustard seed-air   Particle size: 14/20 BSS
h_s = 12 cms.   h= 36 cms   R= 3.0   t = 24.5°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.5 CCl_4	23.8	1.7 CCl_4	1.30 CCl_4	0.78	490	-	-
2	2.1 "	33.3	3.7 "	1.92 "	1.15	722	-	-
3	3.1 "	49.1	7.2 "	2.68 "	1.61	1012	-	-
4	4.5 "	71.3	13.2 "	3.64 "	2.20	1385	-	-
5	5.3 "	84.0	26.1 "	5.11 "	3.10	1950	-	-
6	5.5 "	87.1	31.6 "	5.63 "	3.41	2145	-	-
7	5.7 "	90.4	48.9 "	7.00 "	4.25	2670	-	-
8	5.9 "	93.5	9.4 Hg	3.06 Hg	5.51	3468	-	-
9	6.9 "	109.3	13.5 "	3.68 "	6.61	4160	-	-
10	12.1 "	191.8	16.6 "	4.07 "	7.34	4610	1.5	0.125
11	17.7 "	280.5	20.1 "	4.49 "	8.07	5075	3.0	0.250
12	24.1 "	382.0	27.8 "	5.27 "	9.50	5975	4.0	0.333
13	38.2 "	605.0	37.1 "	6.10 "	11.00	6910	6.3	0.525

TABLE-3.B_{128}

System: Mustard seed-air   Particle size : 14/20 BSS
h_s =12 cms.   h = 42 cms.   R = 3.5   t= 25°C

1	2	3	4	5	6	7	8	9
1	1.5 CCl_4	23.8	2.3 CCl_4	1.51 CCl_4	0.91	572	-	-
2	2.3 "	36.5	5.5 "	2.34 "	1.40	880	-	-
3	3.4 "	53.9	9.8 "	3.13 "	1.89	1190	-	-
4	4.9 "	77.6	17.1 "	4.14 "	2.50	1572	-	-
5	5.3 "	84.0	30.1 "	5.50 "	3.33	2095	-	-
6	5.6 "	88.7	55.3 "	7.45 "	4.53	2850	-	-
7	5.9 "	93.5	11.9 Hg	3.45 Hg	6.20	3900	-	-
8	8.3 "	131.5	19.4 "	4.40 "	7.90	4960	-	-
9	12.9 "	204.5	21.3 "	4.61 "	8.30	5215	1.5	0.125
10	17.5 "	277.0	26.8 "	5.17 "	9.30	5850	2.5	0.208
11	33.5 "	531.0	37.6 "	6.14 "	11.04	6940	4.2	0.350
12	41.8 "	662.5	44.5 "	6.67 "	12.00	7540	5.4	0.450

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{129}

System: Sago-air Particle size: 14/20 BSS
h_s = 10 cms. h= 20 cms. R= 2.0 t= 22.5°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	0.8 CCl_4	12.7	0.6 CCl_4	0.77 CCl_4	0.45	283	-	-
2	1.2 "	19.0	1.6 "	1.26 "	0.75	472	-	-
3	2.6 "	41.2	5.2 "	2.28 "	1.37	861	-	-
4	4.8 "	76.1	18.9 "	4.35 "	2.12	1333	-	-
5	5.1 "	80.9	23.8 "	4.88 "	2.95	1855	-	-
6	5.2 "	82.4	36.8 "	6.06 "	3.68	2325	-	-
7	5.3 "	84.0	43.8 "	6.61 "	4.01	2524	-	-
8	5.6 "	88.7	49.6 "	7.05 "	4.28	2690	-	-
9	7.8 "	123.6	7.4 Hg	2.72 Hg	4.90	3080	1.5	0.150
10	9.8 "	155.3	9.2 "	3.03 "	5.45	3425	2.5	0.250
11	13.0 "	206.0	11.9 "	3.45 "	6.20	3900	4.0	0.400
12	15.6 "	247.2	16.1 "	4.01 "	7.22	4540	5.0	0.500
13	19.8 "	314.0	25.2 "	5.02 "	9.03	5680	6.0	0.600

TABLE-3.B_{130}

System: Sago-air Particle size: 14/20 BSS
h_s = 10 cms. h= 25 cms. R= 2.5 t= 23°C

1	2	3	4	5	6	7	8	9
1	0.9 CCl_4	14.3	1.4 CCl_4	1.18 CCl_4	0.70	440	-	-
2	1.3 "	20.6	2.8 "	1.67 "	1.00	629	-	-
3	2.1 "	33.3	5.7 "	2.39 "	1.43	899	-	-
4	2.9 "	46.0	9.7 "	3.12 "	1.88	1182	-	-
5	4.3 "	68.1	16.4 "	4.05 "	2.45	1540	-	-
6	5.1 "	80.9	28.2 "	5.31 "	3.21	2020	-	-
7	5.5 "	87.1	55.8 "	7.46 "	4.53	2850	-	-
8	6.7 "	106.2	8.8 Hg	2.96 Hg	5.17	3255	-	-
9	8.3 "	131.5	10.4 "	3.22 "	5.80	3650	1.0	0.100
10	9.7 "	153.8	12.0 "	3.47 "	6.24	3920	2.0	0.200
11	14.1 "	223.5	17.9 "	4.24 "	7.60	4780	3.5	0.350
12	22.8 "	361.5	30.6 "	5.54 "	9.98	6275	5.8	0.580

VARIATION OF PRESSURE DROP AND PACKED BED FORMATION(BELOW THE TOP RESTRAINT) WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

TABLE-3.B_{131}

System: Sago-air Particle size: 14/20 BSS
h_s = 10 cms. h= 30 cms. R = 3.0 t= 24°C

Sl. No.	ΔH_1 Cms.	ΔP Kg/M^2	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ $Cms.^{\frac{1}{2}}$	W Kg/hr.	G $Kg/hr.m^2$	h_{pa} Cms.	h_{pa}/h_s
1	2	3	4	5	6	7	8	9
1	1.3 CCl_4	20.6	2.6 CCl_4	1.61 CCl_4	0.97	610	-	-
2	1.9 "	30.1	5.2 "	2.28 "	1.37	860	-	-
3	2.7 "	42.8	8.9 "	2.98 "	1.80	1131	-	-
4	4.5 "	71.3	19.0 "	4.36 "	2.64	1660	-	-
5	5.1 "	80.9	31.0 "	5.56 "	3.37	2120	-	-
6	5.2 "	82.4	38.1 "	6.17 "	3.75	2360	-	-
7	5.3 "	84.0	49.2 "	7.02 "	4.26	2680	-	-
8	5.5 "	87.1	9.5 Hg	3.08 Hg	5.55	3490	-	-
9	6.3 "	99.9	11.9 "	3.45 "	6.20	3900	-	-
10	9.5 "	150.5	16.3 "	4.04 "	7.25	4560	1.2	0.120
11	12.7 "	201.2	18.8 "	4.34 "	7.80	4900	2.2	0.220
12	19.3 "	306.0	25.0 "	5.00 "	9.00	5660	3.8	0.380
13	26.0 "	411.5	34.2 "	5.85 "	10.55	6615	5.2	0.520

TABLE-3.B_{132}

System: Sago-air Particle size: 14/20 BSS
h_s = 10 cms. h = 35 cms. R= 3.5 t = 25°C

1	2	3	4	5	6	7	8	9
1	1.1 CCl_4	17.4	2.0 CCl_4	1.41 CCl_4	0.85	535	-	-
2	1.7 "	27.0	4.8 "	2.19 "	1.31	823	-	-
3	2.5 "	39.6	8.6 "	2.94 "	1.76	1108	-	-
4	4.1 "	65.0	16.7 "	4.09 "	2.46	1548	-	-
5	5.1 "	80.9	22.8 "	4.78 "	2.89	1818	-	-
6	5.0 "	79.2	27.2 "	5.22 "	3.15	1980	-	-
7	5.2 "	82.4	37.1 "	6.10 "	3.70	2325	-	-
8	5.3 "	84.0	52.3 "	7.25 "	4.40	2765	-	-
9	5.6 "	88.7	13.1 Hg	3.62 Hg	6.52	4100	-	-
10	10.3 "	163.2	21.8 "	4.67 "	8.40	5280	1.0	0.100
11	19.1 "	302.5	27.0 "	5.20 "	9.40	5910	3.0	0.300
12	24.1 "	382.0	32.4 "	5.70 "	10.28	6450	4.5	0.450

TABLE-3.C_1

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Salt-air   Particle size: 20/30 BSS

w = 64.6597 gms. h_s = 4.8 cms. V_s = 30.8 cc.

ϵ_{pa} = 0.596   t = 19°C

Sl. No.	ΔH_2 Cms.		$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$		W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	14.2	CCl_4	3.76	CCl_4	2.26	1420	5.0	1.040	0.960	0.612
2	26.4	"	5.14	"	3.10	1950	5.8	1.210	0.828	0.664
3	32.0	"	5.65	"	3.42	2152	6.2	1.290	0.774	0.688
4	37.7	"	6.14	"	3.72	2340	6.5	1.355	0.738	0.702
5	43.1	"	6.56	"	3.98	2505	6.8	1.417	0.705	0.715
6	6.7	Hg	2.59	Hg	4.68	2945	7.8	1.625	0.615	0.752
7	8.3	"	2.88	"	5.20	3270	8.4	1.750	0.571	0.770
8	10.0	"	3.16	"	5.70	3585	9.5	1.980	0.505	0.796
9	11.7	"	3.42	"	6.15	3870	10.1	2.100	0.475	0.808
10	13.2	"	3.64	"	6.53	4110	11.0	2.290	0.436	0.824
11	15.9	"	3.99	"	7.20	4530	11.9	2.480	0.403	0.837
12	19.1	"	4.37	"	7.88	4955	13.0	2.706	0.369	0.851
13	23.3	"	4.83	"	8.70	5470	14.5	3.020	0.331	0.866
14	27.3	"	5.22	"	9.40	5910	16.5	3.440	0.291	0.882
15	31.8	"	5.64	"	10.16	6390	17.3	3.600	0.277	0.888
16	38.5	"	6.20	"	11.18	7030	18.6	3.870	0.258	0.896
17	46.9	"	6.85	"	12.32	7750	22.6	4.700	0.212	0.915

TABLE-3.C2

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Salt-air   Particle size: 20/40 BSS

w = 60.8092 gms. h_s = 4.4 cms. V_s = 28.9 cc.

ϵ_{pa} = 0.588 t = 22°C

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	8.2 CCl_4	2.86 CCl_4	1.73	1088	5.3	1.205	0.830	0.658
2	11.1 "	3.33 "	2.01	1264	5.6	1.270	0.785	0.676
3	15.4 "	3.92 "	2.37	1490	6.0	1.365	0.734	0.698
4	21.7 "	4.66 "	2.82	1773	6.5	1.480	0.676	0.721
5	31.7 "	5.64 "	3.41	2145	7.5	1.705	0.586	0.758
6	40.7 "	6.39 "	3.88	2440	8.5	1.930	0.518	0.786
7	7.0 Hg	2.64 Hg	4.78	3005	10.5	2.380	0.419	0.827
8	9.6 "	3.10 "	5.60	3520	12.5	2.840	0.352	0.851
9	12.8 "	3.58 "	6.45	4055	14.0	3.180	0.314	0.871
10	15.6 "	3.88 "	7.00	4400	16.0	3.640	0.275	0.887
11	20.0 "	4.47 "	8.02	5050	18.5	4.200	0.238	0.902
12	24.1 "	4.91 "	8.85	5560	21.0	4.770	0.209	0.914
13	28.4 "	5.33 "	9.60	6040	25.0	5.450	0.176	0.927

TABLE-3.C$_3$

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Salt-air Particle size: 40/52 BSS

$w = 64.8070$ gms. $h_s = 4.4$ cms. $V_s = 30.8$ cc.

$\epsilon_{pa} = 0.560$ $t = 20^{o}C$

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	3.9 CCl_4	1.97 CCl_4	1.18	741	4.9	1.113	0.898	0.605
2	10.7 "	3.27 "	1.97	1240	6.2	1.410	0.710	0.688
3	15.7 "	3.96 "	2.39	1502	6.7	1.522	0.656	0.711
4	21.3 "	4.61 "	2.80	1760	7.5	1.705	0.586	0.742
5	29.8 "	5.45 "	3.30	2075	8.5	1.930	0.517	0.772
6	37.4 "	6.11 "	3.71	2335	9.5	2.160	0.463	0.796
7	44.2 "	6.65 "	4.03	2535	10.5	2.385	0.419	0.816
8	6.0 Hg	2.45 Hg	4.40	2768	11.2	2.545	0.392	0.827
9	7.8 "	2.79 "	5.00	3145	12.4	2.820	0.355	0.844
10	10.4 "	3.22 "	5.80	3650	14.0	3.180	0.314	0.862
11	13.1 "	3.62 "	6.50	4090	16.0	3.635	0.275	0.879
12	16.6 "	4.07 "	7.33	4610	19.0	4.315	0.232	0.898
13	20.6 "	4.54 "	8.18	5150	22.4	5.090	0.196	0.913
14	26.6 "	5.16 "	9.30	5850	26.0	5.910	0.169	0.925

TABLE-3.C_4

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Salt-air Particle size: 52/60 BSS

w = 62.3378 gms. h_s = 4.0 cms. V_s = 29.7cc.

ϵ_{pa} = 0.533 $t = 19^oC$

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{1/2}$	W Kg/hr.	G Kg/hr.m^2	hf Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	1.7 CCl_4	1.30 CCl_4	0.78	491	4.5	1.125	0.890	0.586
2	3.3 "	1.82 "	1.09	685	5.0	1.250	0.800	0.626
3	5.1 "	2.26 "	1.35	849	5.3	1.325	0.755	0.647
4	8.1 "	2.84 "	1.72	1080	5.7	1.425	0.702	0.672
5	13.4 "	3.66 "	2.21	1390	6.6	1.650	0.606	0.707
6	17.1 "	4.14 "	2.50	1570	7.2	1.800	0.555	0.740
7	21.9 "	4.68 "	2.83	1780	7.8	1.950	0.513	0.760
8	28.6 "	5.35 "	3.24	2035	9.0	2.250	0.445	0.792
9	36.6 "	6.05 "	3.67	2360	10.5	2.625	0.381	0.822
10	6.2 Hg	2.49 Hg	4.48	2815	12.0	3.000	0.333	0.849
11	8.6 "	2.93 "	5.25	3300	13.0	3.250	0.308	0.856
12	11.9 "	3.45 "	6.20	3895	15.0	3.750	0.267	0.875
13	14.7 "	3.84 "	6.90	4340	16.5	4.120	0.242	0.887
14	18.7 "	4.32 "	7.78	4890	19.0	4.750	0.210	0.902
15	23.5 "	4.85 "	8.75	5500	23.0	5.750	0.174	0.918

TABLE-3.C_5

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Ammonium sulphate-air   Particle size: 30/40 BSS

w = 90.633 gms. h_s = 5.2 cms. V_s = 51.5 cc.

ϵ_{pa} = 0.377 t = 25°C

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	4.1 CCl_4	2.03 CCl_4	1.21	760	5.8	1.115	0.896	0.442
2	7.4 "	2.72 "	1.64	1032	6.3	1.210	0.825	0.486
3	11.1 "	3.34 "	2.00	1258	6.6	1.270	0.788	0.510
4	14.7 "	3.84 "	2.31	1453	7.2	1.384	0.722	0.550
5	20.4 "	4.52 "	2.74	1723	8.0	1.540	0.650	0.595
6	26.4 "	5.14 "	3.10	1950	9.0	1.730	0.578	0.640
7	34.2 "	5.85 "	3.55	2236	10.2	1.960	0.510	0.682
8	46.9 "	6.85 "	4.15	2610	11.8	2.270	0.440	0.726
9	7.3 Hg	2.70 Hg	4.87	3065	13.5	2.600	0.385	0.760
10	11.0 "	3.32 "	5.99	3766	15.5	2.980	0.336	0.791
11	17.3 "	4.16 "	7.50	4720	18.0	3.460	0.289	0.820
12	23.5 "	4.85 "	8.75	5500	20.5	3.940	0.254	0.842
13	30.4 "	5.51 "	9.93	6250	23.0	4.420	0.226	0.859

TABLE-3.C_6

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Sand-air   Particle size: 30/40 BSS

w = 122.379 gms. h_s = 5.3 cms. V_s = 46.2 cc.

ϵ_{pa} = 0.451 t = 26°C

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	4.2 CCl_4	2.05 CCl_4	1.24	780	5.9	1.112	0.899	0.506
2	8.9 "	2.98 "	1.80	1130	6.2	1.170	0.855	0.531
3	14.2 "	3.77 "	2.28	1433	6.6	1.245	0.802	0.560
4	17.8 "	4.22 "	2.55	1603	7.0	1.320	0.757	0.585
5	22.2 "	4.71 "	2.85	1790	8.0	1.510	0.663	0.636
6	28.6 "	5.35 "	3.25	2045	8.6	1.622	0.616	0.662
7	37.0 "	6.08 "	3.68	2315	9.6	1.810	0.552	0.697
8	46.0 "	6.78 "	4.12	2590	10.4	1.962	0.510	0.720
9	6.8 Hg	2.61 Hg	4.70	2960	11.4	2.150	0.465	0.745
10	9.5 "	3.08 "	5.55	3490	12.5	2.360	0.424	0.768
11	13.2 "	3.63 "	6.52	4100	13.5	2.545	0.393	0.784
12	16.4 "	4.05 "	7.30	4590	14.5	2.740	0.365	0.799
13	20.3 "	4.50 "	8.10	5095	15.5	2.925	0.342	0.812
14	24.0 "	4.90 "	8.82	5550	16.5	3.110	0.321	0.824
15	31.4 "	5.60 "	10.10	6350	18.0	3.400	0.294	0.839
16	36.1 "	6.01 "	10.84	6815	19.2	3.620	0.276	0.849

TABLE-3.C_7

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-NON-SPHERICAL PARTICLES

System: Magnesite-air Particle size: 30/40 BSS

w = 123.9898 gms. h_s= 5.0 cms. V_s = 44.28 cc.

ϵ_{pa} = 0.443 t = 26^oC

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	9.4 CCl_4	3.07 CCl_4	1.85	1162	5.7	1.14	0.877	0.511
2	14.1 "	3.76 "	2.27	1428	6.0	1.20	0.833	0.536
3	20.6 "	4.54 "	2.74	1722	6.3	1.26	0.794	0.558
4	25.5 "	5.05 "	3.05	1918	6.6	1.32	0.757	0.578
5	30.5 "	5.52 "	3.35	2105	6.9	1.38	0.725	0.596
6	37.8 "	6.15 "	3.73	2345	7.5	1.50	0.666	0.628
7	47.4 "	6.89 "	4.17	2620	8.5	1.70	0.588	0.672
8	6.7 Hg	2.59 Hg	4.64	2915	10.2	2.04	0.490	0.727
9	8.1 "	2.84 "	5.10	3205	11.2	2.14	0.446	0.751
10	10.5 "	3.24 "	5.80	3645	12.8	2.56	0.390	0.783
11	14.4 "	3.80 "	6.90	4340	14.0	2.80	0.357	0.801
12	18.3 "	4.27 "	7.70	4900	15.5	3.10	0.323	0.820
13	22.4 "	4.73 "	8.50	5345	17.0	3.40	0.294	0.836
14	29.7 "	5.45 "	9.80	6160	19.0	3.80	0.263	0.853
15	34.0 "	5.83 "	10.50	6600	20.5	4.10	0.244	0.864

TABLE-3.C_8

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

System: Mustard seed-air   Particle size: 14/20 BSS

$w = 68.14$ gms. $h_s = 6.0$ cms. $V_s = 60.9$ cc.

$\epsilon_{pa} = 0.362$ $t = 26^oC$

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	15.4 CCl_4	3.92 CCl_4	2.37	1490	6.8	1.132	0.882	0.437
2	21.3 "	4.61 "	2.79	1755	7.1	1.182	0.845	0.461
3	27.1 "	5.20 "	3.15	1980	7.7	1.282	0.779	0.504
4	32.2 "	5.67 "	3.43	2160	8.3	1.382	0.723	0.539
5	41.0 "	6.40 "	3.88	2440	9.0	1.500	0.666	0.575
6	50.4 "	7.10 "	4.31	2710	10.5	1.750	0.571	0.636
7	7.7 Hg	2.78 Hg	5.00	3145	11.5	1.915	0.521	0.667
8	11.2 "	3.35 "	6.02	3785	13.0	2.165	0.461	0.706
9	14.1 "	3.76 "	6.88	4325	14.0	2.330	0.429	0.727
10	18.6 "	4.31 "	7.88	4950	15.5	2.580	0.387	0.753
11	22.9 "	4.79 "	8.63	5426	17.0	2.830	0.353	0.775
12	31.1 "	5.58 "	10.05	6310	20.5	3.420	0.293	0.813
13	35.1 "	5.93 "	10.68	6710	22.5	3.750	0.267	0.830

TABLE-3.C_9

VARIATION OF EXPANDED BED HEIGHT AND BED POROSITY WITH FLUID MASS VELOCITY-SPHERICAL PARTICLES

System: Sago-air Particle size: 14/20 BSS

w = 88.6823 gms. h_s = 6.8 cms. V_s = 68.0 cc.

ϵ_{pa} = 0.380 $t = 26^{o}C$

Sl. No.	ΔH_2 Cms.	$\sqrt{\Delta H_2}$ Cms.$^{\frac{1}{2}}$	W Kg/hr.	G Kg/hr.m^2	h_f Cms.	h_f/h_s	h_s/h_f	ϵ_f
1	21.2 CCl_4	4.71 CCl_4	2.85	1790	7.4	1.090	0.919	0.430
2	26.3 "	5.12 "	3.10	1950	7.7	1.132	0.883	0.452
3	30.8 "	5.55 "	3.37	2120	8.1	1.190	0.840	0.479
4	36.4 "	6.04 "	3.66	2300	8.7	1.280	0.782	0.515
5	43.9 "	6.62 "	4.01	2520	9.6	1.412	0.709	0.560
6	6.8 Hg	2.61 Hg	4.70	2955	11.0	1.620	0.618	0.616
7	8.7 "	2.95 "	5.30	3330	12.0	1.765	0.566	0.648
8	11.7 "	3.42 "	6.16	3880	14.0	2.060	0.486	0.698
9	14.8 "	3.84 "	6.90	4340	16.0	2.350	0.425	0.736
10	20.0 "	4.47 "	8.04	5050	18.0	2.650	0.378	0.766
11	24.2 "	4.92 "	8.86	5570	20.0	2.940	0.340	0.789
12	32.4 "	5.69 "	10.24	6440	22.0	3.240	0.309	0.808

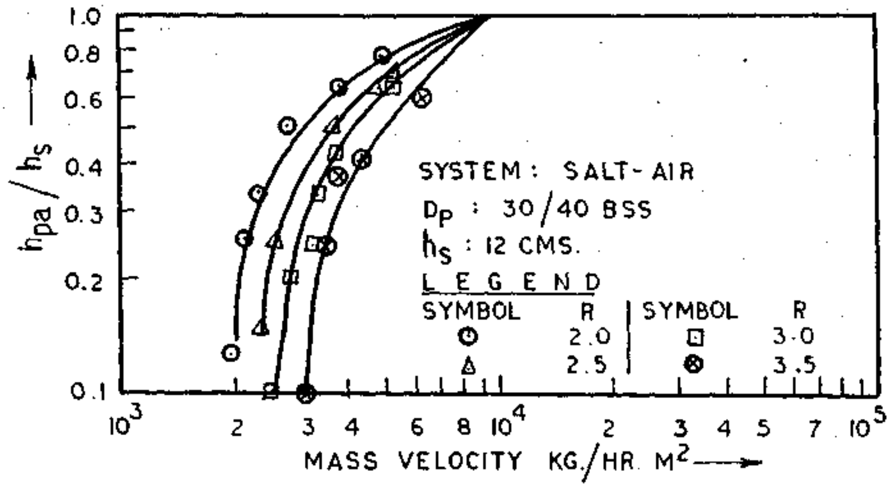


FIG. 3 a_1 EFFECT OF BED EXPANSION RATIO ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

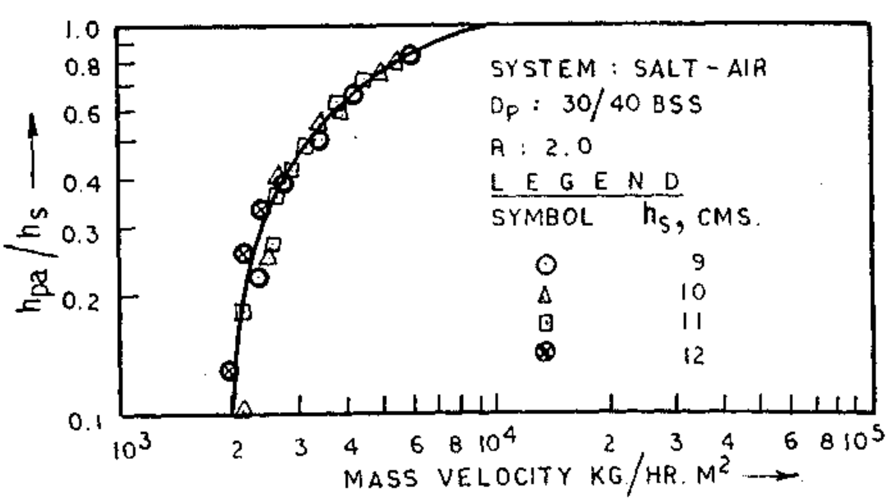


FIG. 3 a_2 EFFECT OF STATIC BED HEIGHT ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

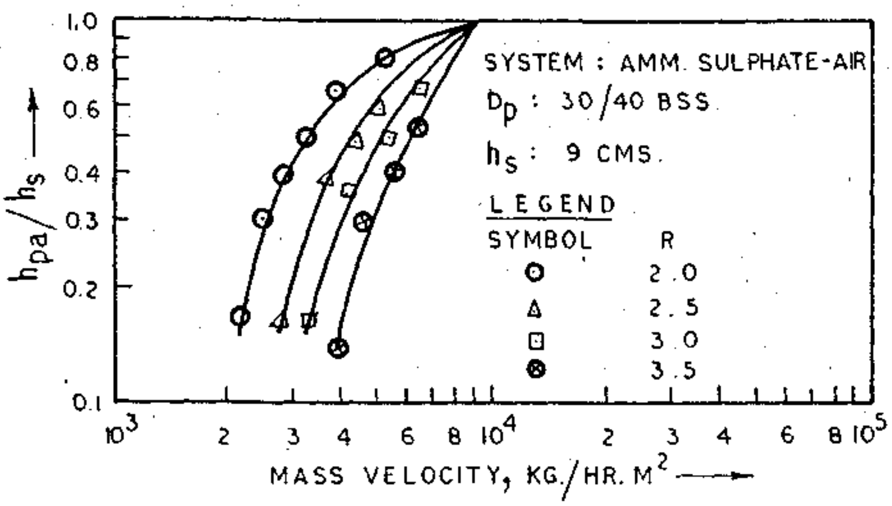


FIG. 3a$_3$ EFFECT OF BED EXPANSION RATIO ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

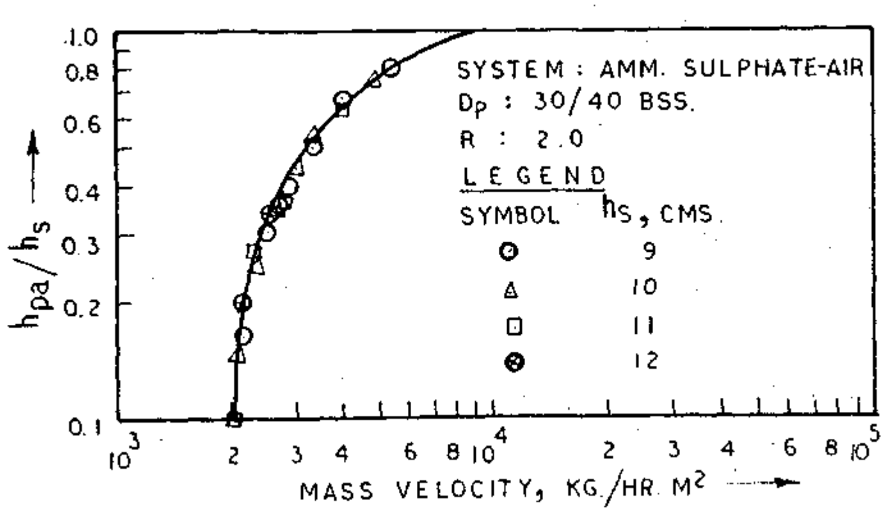


FIG. 3a$_4$ EFFECT OF STATIC BED HEIGHT ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

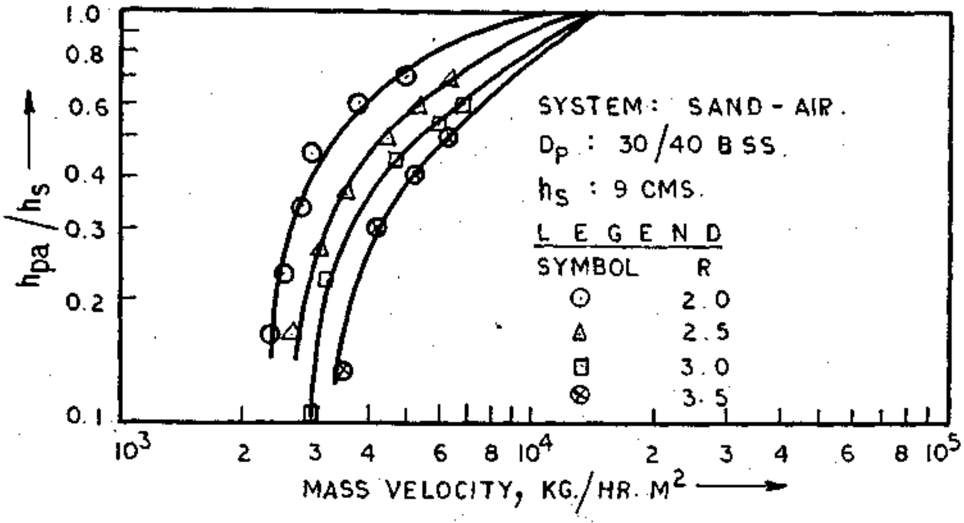


FIG. 3a$_5$ EFFECT OF BED EXPANSION RATIO ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

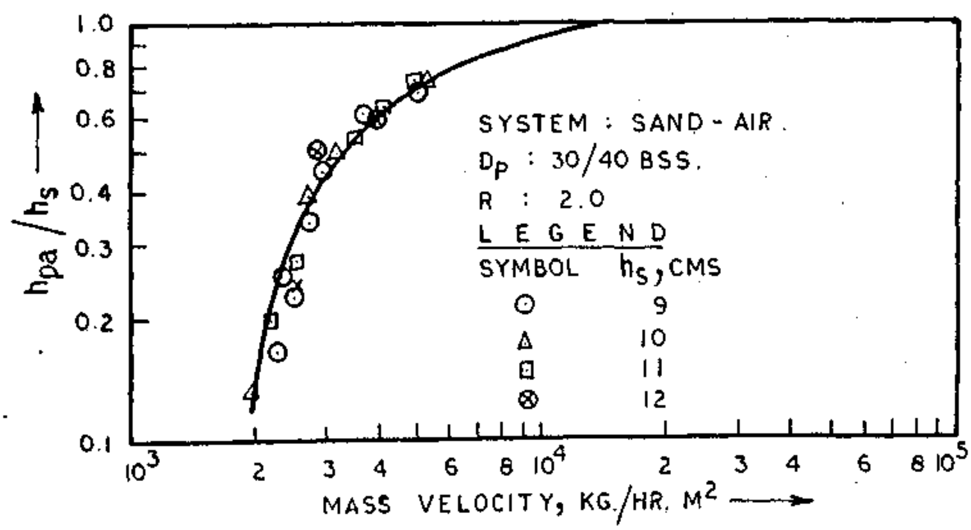


FIG. 3a$_6$ EFFECT OF STATIC BED HEIGHT ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

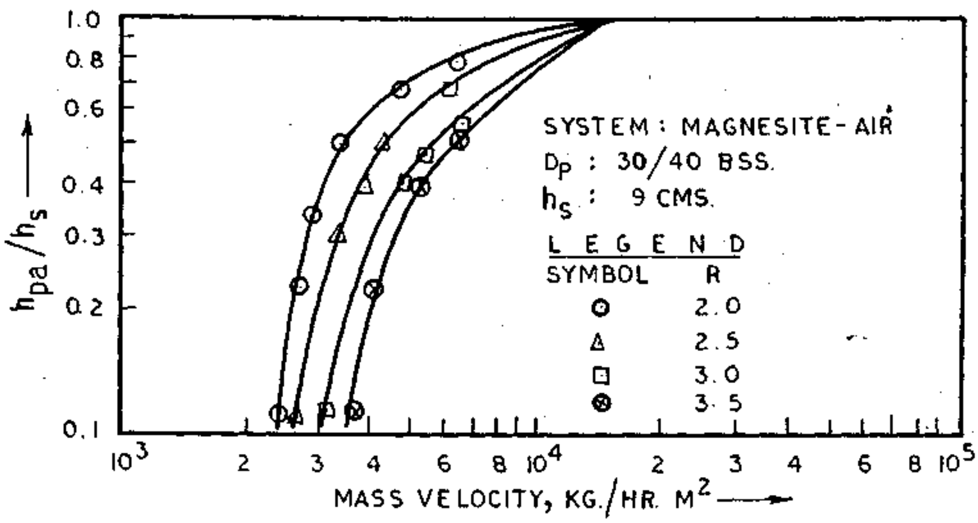


FIG. 3a7 EFFECT OF BED EXPANSION RATIO ON MAX.M SEMI-FLUIDIZATION VELOCITY.

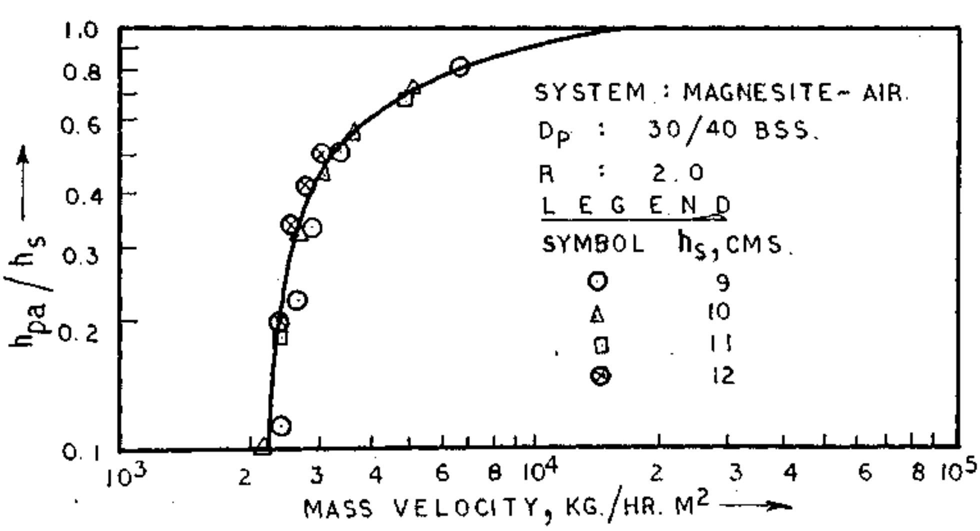


FIG. 3a8 EFFECT OF STATIC BED HEIGHT ON MAX.M SEMI-FLUIDIZATION VELOCITY.

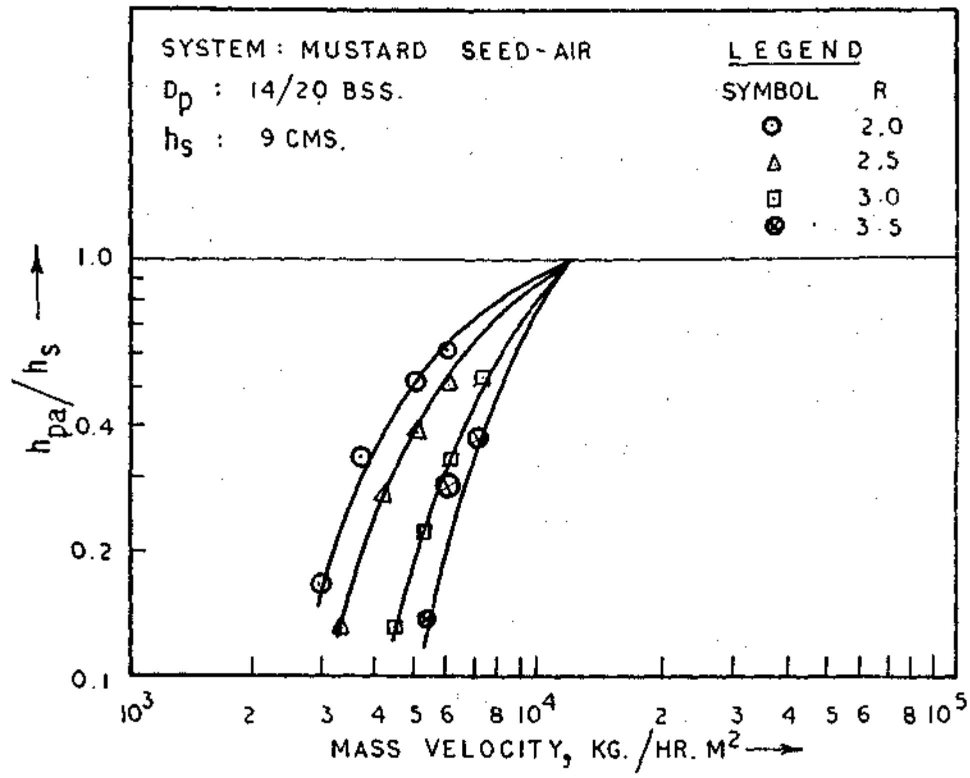


FIG. 3 a_9 EFFECT OF BED EXPANSION RATIO ON MAX^M SEMI-FLUIDIZATION VELOCITY.

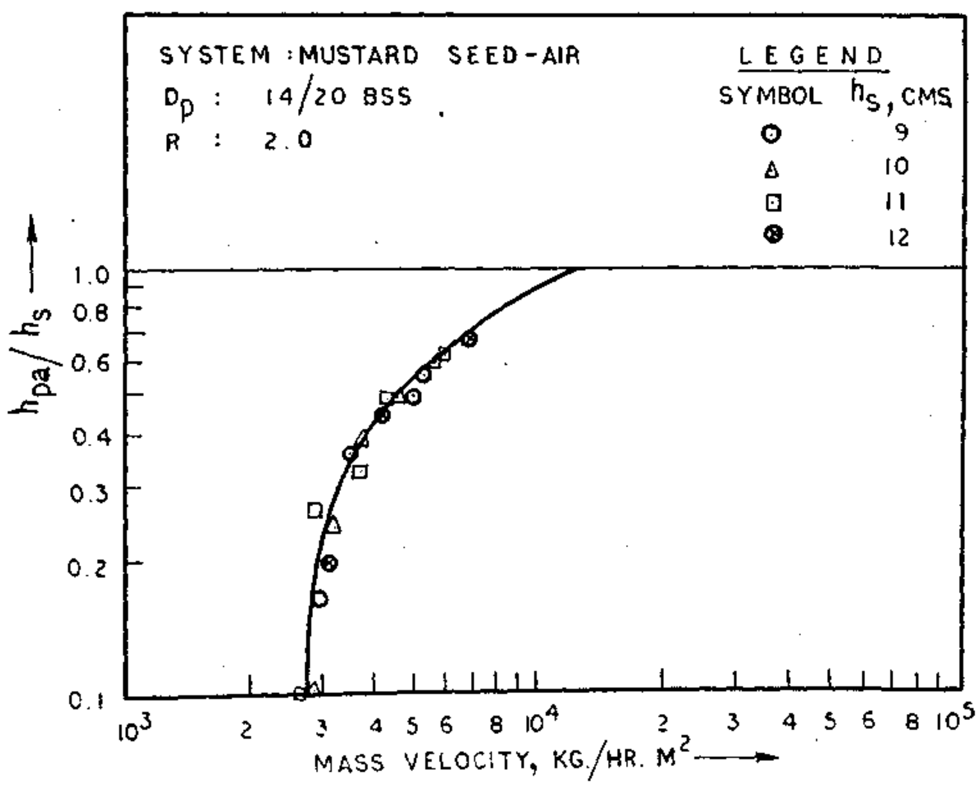


FIG. 3 a_{10} EFFECT OF STATIC BED HEIGHT ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

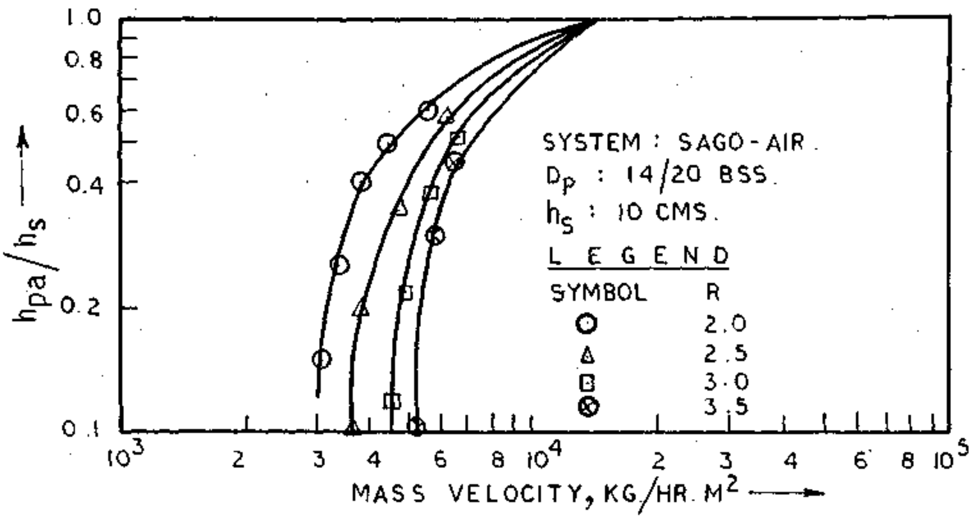


FIG. 3a11 EFFECT OF BED EXPANSION RATIO ON MAX.M SEMI-FLUIDIZATION VELOCITY.

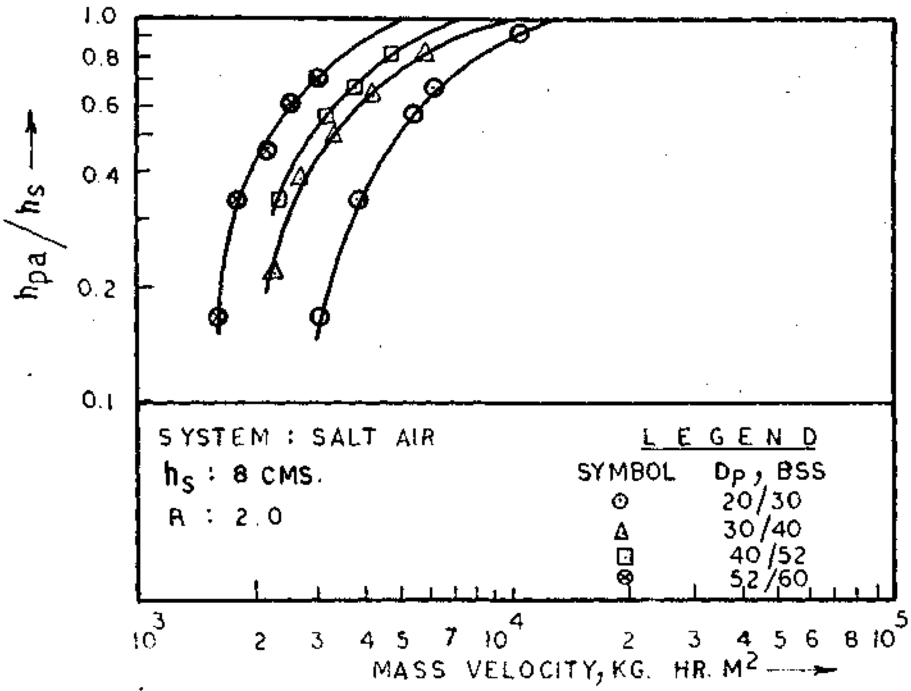


FIG. 3 a_{12} EFFECT OF PARTICLE SIZE ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

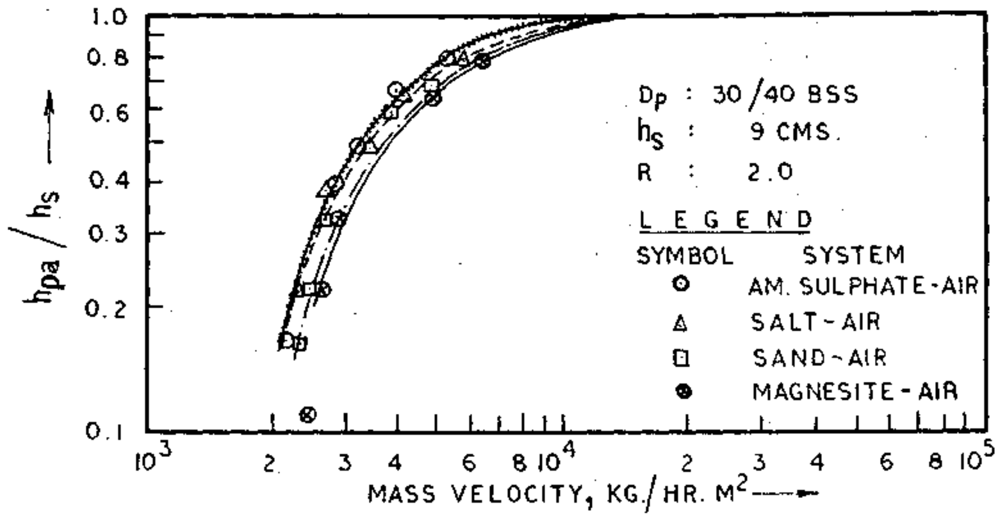


FIG. 3a$_{13}$ EFFECT OF PARTICLE DENSITY (NON-SPHERICAL) ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

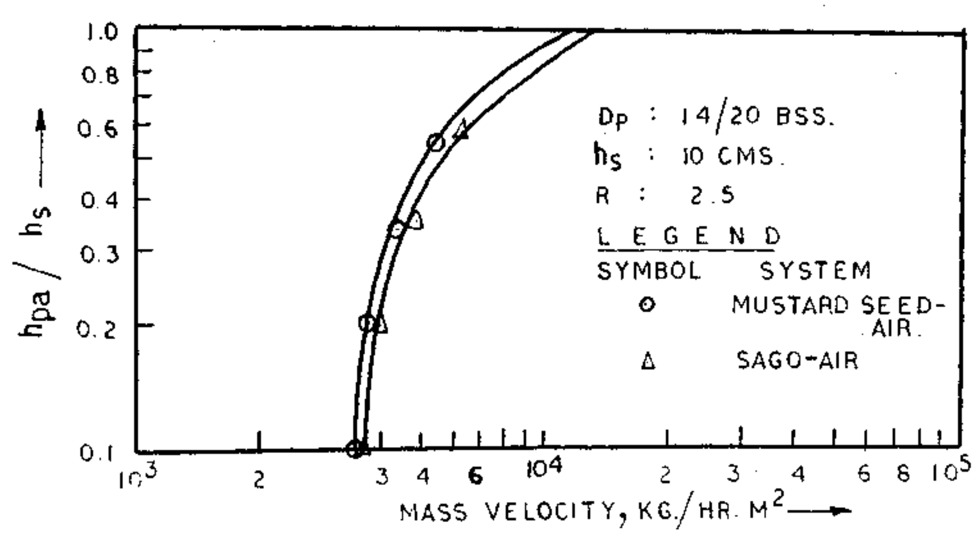


FIG. 3a$_{14}$ EFFECT OF PARTICLE DENSITY (SPHERICAL) ON MAX.^{M} SEMI-FLUIDIZATION VELOCITY.

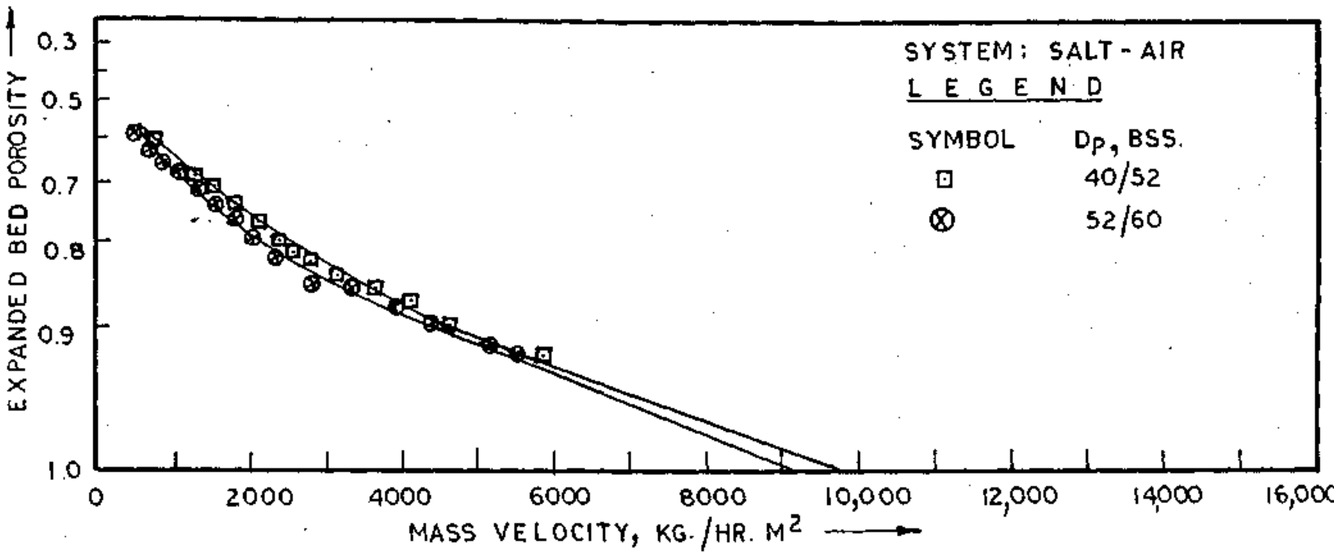


FIG. 3a15 EFFECT OF PARTICLE SIZE ON EXPANDED BED POROSITY.

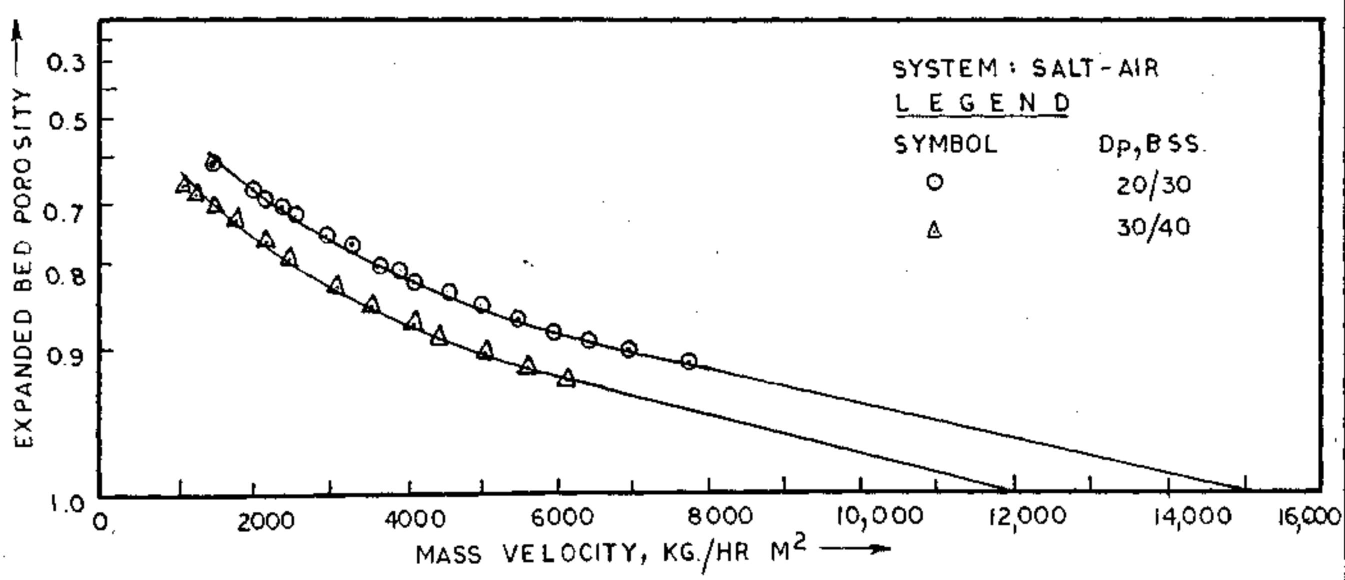


FIG. 3a16 EFFECT OF PARTICLE SIZE ON EXPANDED BED POROSITY.

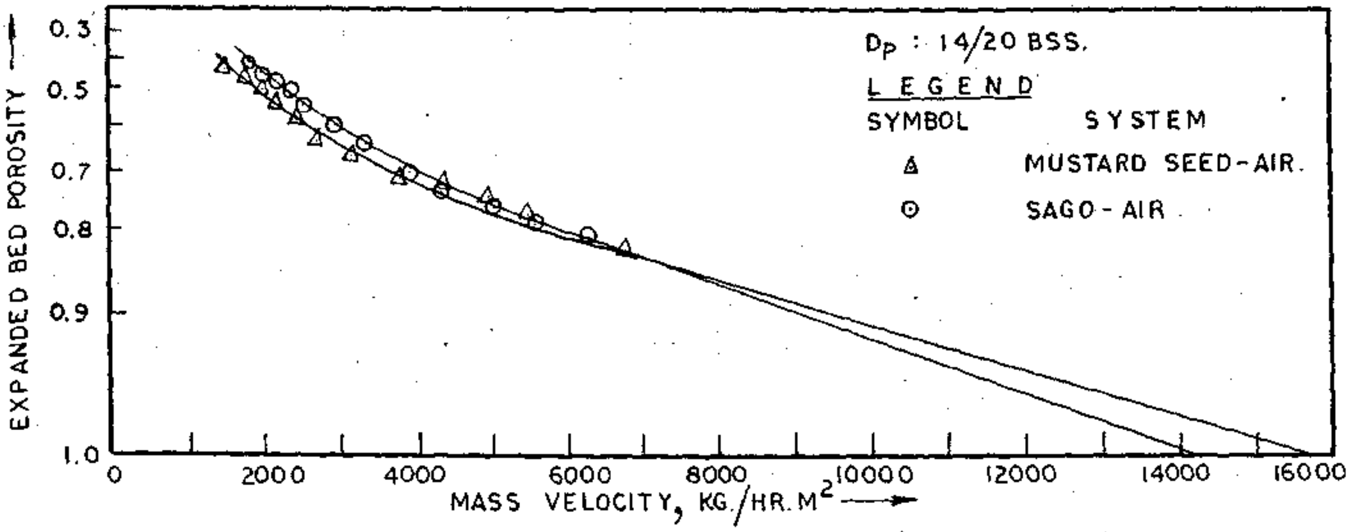


FIG. 3a17 EFFECT OF PARTICLE DENSITY (SPHERICAL) ON EXPANDED BED POROSITY.

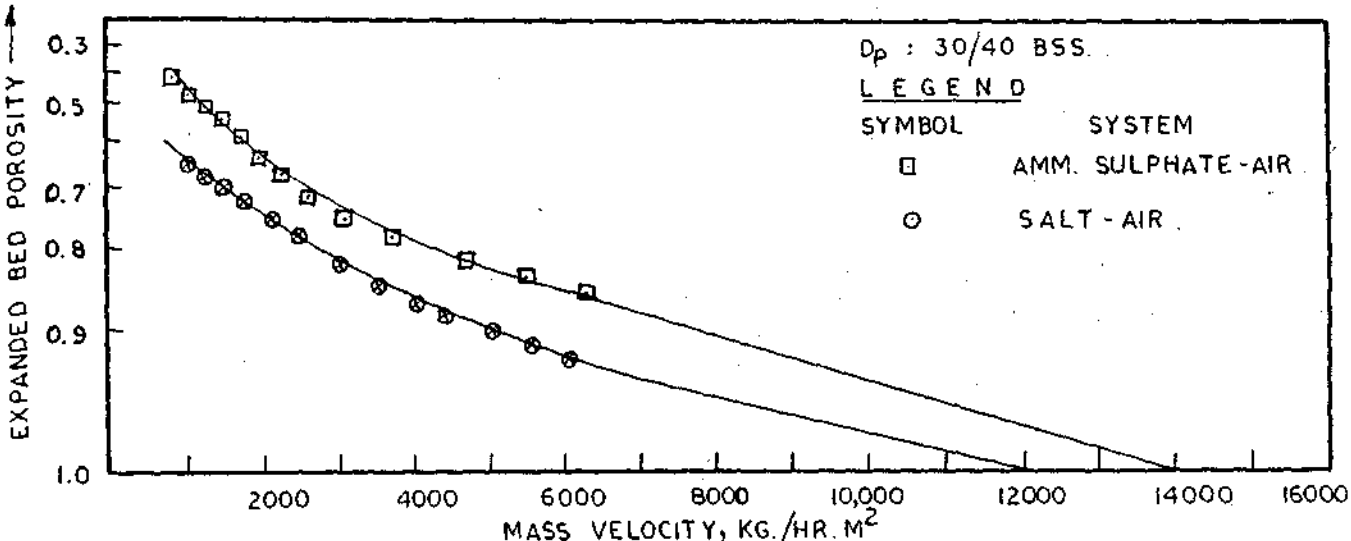


FIG. 3a18 EFFECT OF PARTICLE DENSITY (NON-SPHERICAL) ON EXPANDED BED POROSITY.

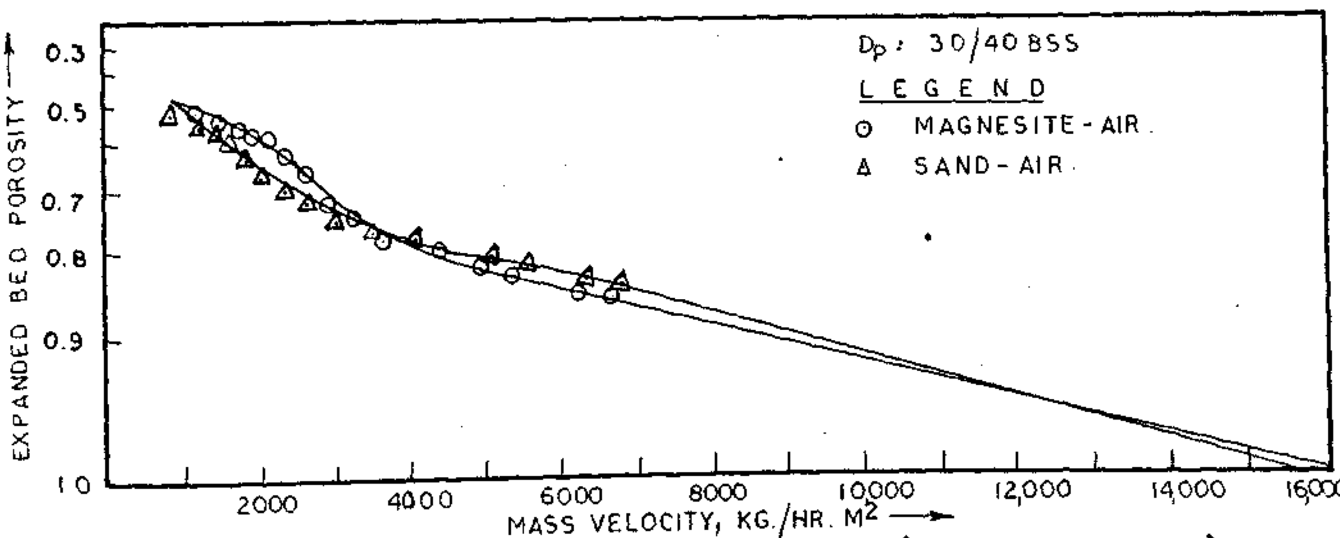


FIG. 3a19 EFFECT OF PARTICLE DENSITY (NON-SPHERICAL) ON EXPANDED BED POROSITY.

It is seen from Table 3.D that comparatively higher values of the maximum semi-fluidization velocity are obtained by extrapolation of ϵ_f vs. G curve. The reason is that the correct evaluation of the. expanded bed voidage is difficult and as a result, the observed values are always lower than the actual ones. This implies that fluid velocity lesser than the predicted value can be used for the complete transfer of the material to the top.

Correlation :

For the gas-solid systems under investigation, it has been found that the effects of the initial static bed height and the position of movable restraint on maximum semi-fluidization velocity were not appreciable (fig. $3.A_1$ - $3.A_{11}$). Similarly the effects of particle size and density on maximum semi-fluidization velocity for spherical and non-spherical particles are given in fig. $3.A_{12}$-$3.A_{14}$. It follows that the parameters of importance are the modified Reynolds number (Re'_{msf}) and the Archimedes number (Ar). The former takes into consideration the effect of velocity, whereas the latter contains terms involving the physical characteristics of the fluid and solid. The relation between the dimensionless groups can be written as -

$$Re'_{msf} = \phi\ (Ar) \qquad \text{.. .. (3.1)}$$

In fig. number $3.A_{20}$, Re'_{msf} has been plotted on a log-log paper against Ar. (Table 3.E) All the data fitted well and a linear relationship is observed. T

$$Re'_{msf} = 1.15 \times 10^{-3}\ (Ar)^{0.676} \qquad \text{.. .. (3.2)}$$

Writing the equation in terms of mass velocity, the maximum semi-fluidization velocity can be given as :

$$G_{msf} = 9.1 \times 10^{2} (d_p)^{1.028} \left[\rho_s (\rho_s - \rho_f) \right]^{0.676} \quad .. \quad .. (3.3)$$

The values of G_{msf} calculated from the above equation has been found to be in good agreement with the experimental data, the percentage deviation for all the cases being within 13%, excepting for one case where it was about 23% . The individual deviations are given in Table 3.F .

Nomograph :

For rapid estimation of the maximum semi-fluidization velocity, a nomograph based on equation(3.3) is given. (Fig. $3.A_{21}$ represents the nomograph). The maximum deviation has been of the order of 9% from the experimental values and 5% from the values calculated by equation, as can be seen from Table 3.G .

B. MINIMUM SEMI-FLUIDIZATION VELOCITY :

It is the minimum fluid velocity at which the first particle of the bed touches the top restraint of the semi-fluidizer. In an actual experiment, it is not possible to visualize this situation exactly. Hence the value of the minimum semi-fluidization velocity is to be obtained indirectly. When the pressure drops across a bed is plotted against fluid mass velocity on a log-log paper, two distinct breaks are marked for the curve. These two points corresponding to the change of slopes indicate the onset of fluidization (G_{mf}) and the onset of semi-fluidization (G_{osf}) velocities in order of occurrence. In the present case, the values of G_{osf} as obtained from plots of ΔP vs. G (Figs. $3.B_1$ -$3.B_{14}$) are given

TABLE -3.D

-Comparison of maximum semi-fluidization velocity-
(Experimental)

Sl. No.	System	d_p m	G_{msf}, Kg/hr.m2 (from h_{pa}/h_s vs G curve for h_{pa}/h_s=1.0)	(from ϵ_f vs G curve for ϵ_f=1.0)
Non-spherical				
1	Table Salt-air	0.000751	14000	15000
2	"	0.000442	10500	12000
3	"	0.000338	7500	9700
4	"	0.000274	5500	9200
5	Ammonium Sulphate-air	0.000442	9000	14000
6	Sand - air	0.000442	14000	15500
7	Magnesite-air	0.000442	15000	16000
Spherical				
8	Mustard Seed-air	0.001105	12400	14200
9	Sago - air	0.001105	14000	15500

TABLE -3.G

-Accuracy of nomograph for G_{msf} -
(in terms of % deviation)

Values of G_{msf}, Kg/hr.m2			Percentage deviation	
Nomograph	Experimental	Calculated	From Expt.value	From Cald.value
9600	10500	10120	-8.56	-5.13

TABLE-3.E

Calculated values of dimensionless groups

Sl. No.	System	Particle size, m	Re'_{msf}	Ar
Non-spherical				
1	Table Salt -air	0.000751	162.5	56.6×10^6
2	"	0.000442	71.6	11.5×10^6
3	"	0.000338	39.2	5.15×10^6
4	"	0.000274	23.3	2.74×10^6
5	Ammonium sulphate-air	0.000442	61.2	8.15×10^6
6	Sand- air	0.000442	95.4	18.4×10^6
7	Magnesite-air	0.000442	102.0	20.5×10^6
Spherical				
8	Mustard seed-air	0.001105	212.0	51.3×10^6
9	Sago-air	0.001105	239.0	69.5×10^6

TABLE-3.F

Comparison of the maximum semi-fluidization velocities

Sl. No.	System	d_p, m	G_{msf} Kg/hr.M^2 (expt.for $h_{pa}/h_s=1$)	G_{msf} Kg/hr.M^2 (calculated)	% deviation of calculated value from the experimental
1.	Table Salt-air	0.000751	14000	17250	+ 23.20
2.	"	0.000442	10500	10180	- 3.05
3.	"	0.000338	7500	7690	+ 2.53
4.	"	0.000274	5500	6160	+ 12.00
5.	Ammonium sulphate-air	0.000442	9000	7990	- 11.20
6.	Sand-air	0.000442	14000	14400	+ 2.86
7.	Magnesite-air	0.000442	15000	14500	- 3.34
8.	Mustard seed-air	0.001105	12400	10840	- 12.60
9.	Sago-air	0.001105	14000	13320	- 4.85

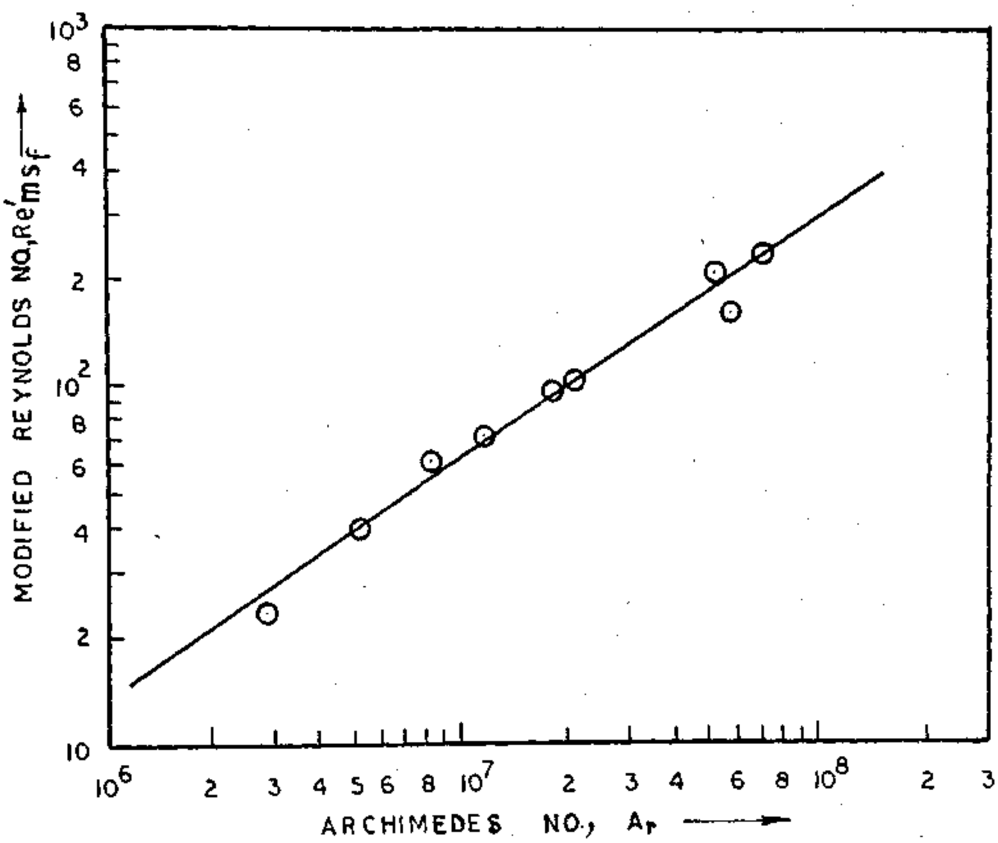


FIG. 3a_{20} PREDICTION OF MAXIMUM SEMI-FLUIDIZATION VELOCITY FROM PHYSICAL PROPERTIES OF THE SYSTEM.

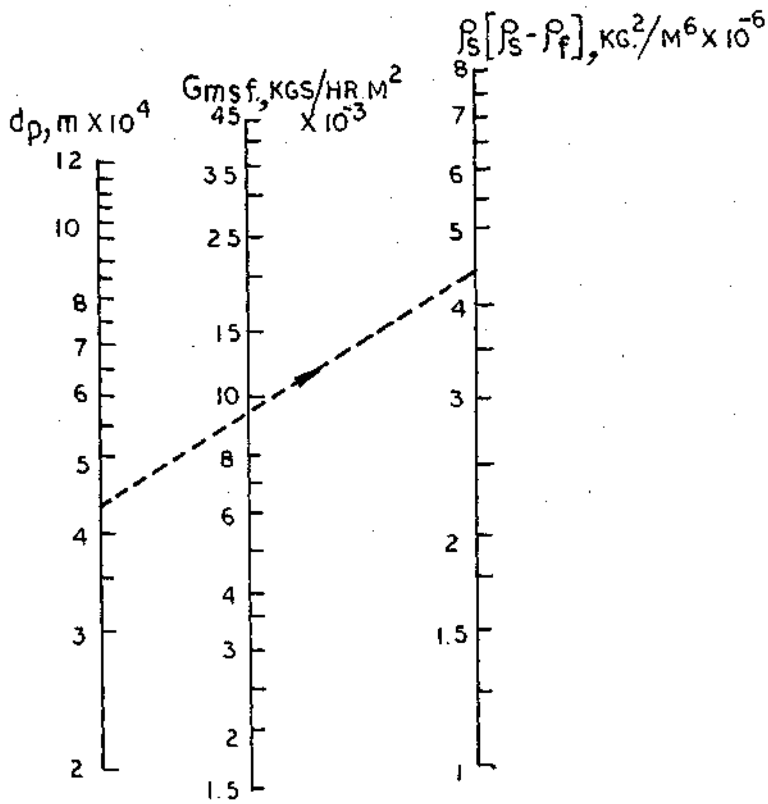


FIG. 3 a_{21} PREDICTION OF MAXIMUM SEMI-FLUIDIZATION VELOCITY.

in Table $3.H_1$ and $3.H_2$.

An alternative method of obtaining the minimum semi-fluidization velocity is to use the expanded bed data. In the h_f/h_s vs. G plots (Fig. $3.B_{15}$ - $3.B_{17}$),.the fluid velocity corresponding to $h_f/h_s = R$, represents the minimum semi-fluidization velocity. The values from expanded bed data, are given in Table 3.I. These values of minimum semi-fluidization velocity, when compared with the same obtained from ΔP vs. G plots, indicate higher values. This is because of the fact that an accurate measurement of expanded bed height in fluidized state presents considerable difficulty.

Correlation :

The parameters of importance for this case are: G_{osf}/G_{msf} , h_s/D_c , D_c/d_p , ρ_s/ρ_f and R . The relation between the group, G_{osf}/G_{msf}, and the other parameters can be written in the following manner:

$$\frac{G_{osf}}{G_{msf}} = \psi \left[\frac{h_s}{D_c} , \frac{D_c}{d_p} , \frac{\rho_s}{\rho_f} , R \right] \quad \ldots \quad \ldots (3.4)$$

It has been observed in course of investigations that the static bed height has no appreciable effect on the onset of semi-fluidization velocity (Table $3.H_1$ and Fig. $3.B_1$ - $3.B_5$.) As a result, an average value of the semi-fluidization velocity (minimum) at a particular bed expansion ratio can be used irrespective of the static bed height (Table $3.H_2$). Also the column diameter has not been altered in the present study. The effect of (h_s/D_c) group is, therefore, not relevant. Consequently,the expression(3.4) reduces to -

$$G_{osf} / G_{msf} = A(D_c/d_p)^{a_1} (\rho_s/ \rho_f)^{a_2} (R)^{a_3} \quad \ldots \quad \ldots (3.5)$$

TABLE-3.H_1

-Experimental minimum semi-fluidization velocities-
(Effect of Particle size.)

System	Bed height h_s, cms.	Minimum semi-fluidization velocity at various bed expansion ratios,(R) Kg/hr.m2 R =2.0	R =2.5	R =3.0	R =3.5
1. Table Salt-air (20/30 BSS)	9.0	2200	2600	2900	3300
	10.0	2200	2700	3100	3300
	11.0	2200	2700	2800	3200
	12.0	2200	2600	2800	3200
2. Table Salt-air (30/40 BSS)	9.0	1900	2000	2300	2600
	10.0	1900	2000	2350	2600
	11.0	1800	2000	2250	2600
	12.0	1800	2000	2200	2600
3. Table Salt-air (40/52 BSS)	9.0	1550	1700	2100	2300
	10.0	1450	1700	2000	2200
	11.0	1450	1650	2000	2200
	12.0	1400	1650	2000	2200
4. Table Salt-air (52/60 BSS)	9.0	1250	1600	1850	2000
	10.0	1250	1550	1850	1900
	11.0	1250	1500	1850	2000
	12.0	1250	1550	1850	1900
Effect of Density of Materials					
5. Ammonium Sulphate-air (30/40 BSS)	9.0	1800	2100	2500	2800
	10.0	1800	2100	2600	2800
	11.0	1700	2000	2500	2900
	12.0	1700	2000	2600	2900
6. Sand-air (30/40 BSS)	9.0	1900	2100	2500	2700
	10.0	1850	2100	2450	2800
	11.0	1850	2000	2500	2700
	12.0	1800	2000	2450	2800
7. Magnesite-air (30/40 BSS)	9.0	1900	2100	2500	2900
	10.0	1850	2000	2500	2900
	11.0	1850	2200	2500	2900
	12.0	1900	2100	2500	2900

contd....

Table-3.H_1
(contd)

Effect of Sphericity of Particles

System	Bed height h_s, cms.	Minimum semi-fluidization velocity at various bed expansion ratios,(R) Kg/hr.m2 R =2.0	R =2.5	R =3.0	R =3.5
8.					
	9.0	2500	2700	3200	4000
Mustard	10.0	2400	2800	3400	4000
Seed-air	11.0	2400	2700	3500	4000
(14/20 BSS)	12.0	2500	3000	3500	4000
9.	9.0	-	-	-	-
Sago-air	10.0	2500	2900	3500	4100
(14/20 BSS)	11.0	-	-	-	-
	12.0	-	-	-	-

TABLE-3.H_2

Average value of minimum semi-fluidization velocities(Experimental)

System	Average value of minimum semi-fluidization velocity at various bed expansion ratios,(R) Kg/hr.m2 R = 2.0	R = 2.5	R= 3.0	R= 3.5
1. Non-Spherical				
Table Salt-air(20/30 BSS)	2200	2650	2900	3250
2. Table Salt-air(30/40BSS)	1850	2000	2275	2600
3. Table Salt-air(40/52BSS)	1462	1675	2025	2225
4. Table Salt-air(52/60BSS)	1250	1550	1850	1950
6. Ammonium Sulphate-air(30/40 BSS)	1750	2050	2550	2850
6. Sand-air (30/40 BSS)	1850	2050	2450	2750
7. Magnesite -air(30/40BSS)	1875	2100	2500	2900
Spherical				
8. Mustard Seed-air(14/20 BSS)	2450	2800	3400	4000
9. Sago-air (14/20 BSS)	2500	2900	3500	4100

TABLE-3.I

-Experimental minimum semi-fluidization velocities-
(From expanded bed data)

System	d_p m.	Minimum semi-fluidization velocity at various bed expansion ratios, (R) Kg/hr. m^2 R =2.0	R =2.5	R =3.0	R =3.5
Non-spherical					
1. Table Salt-air	0.000751	3700	4600	5600	6400
2. "	0.000442	2600	3200	3800	4400
3. "	0.000338	2150	2750	3400	4000
4. "	0.000274	1800	2350	3000	3700
5. Ammonium Sulphate-air	0.000442	2300	3050	3900	4700
6. Sand - air	0.000442	2750	3900	5200	6450
7. Magnesite -air	0.000442	3100	3800	4700	5600
Spherical					
8. Mustard Seed-air	0.001105	3600	4700	5500	6400
9. Sago - air	0.001105	3800	4700	5700	6750

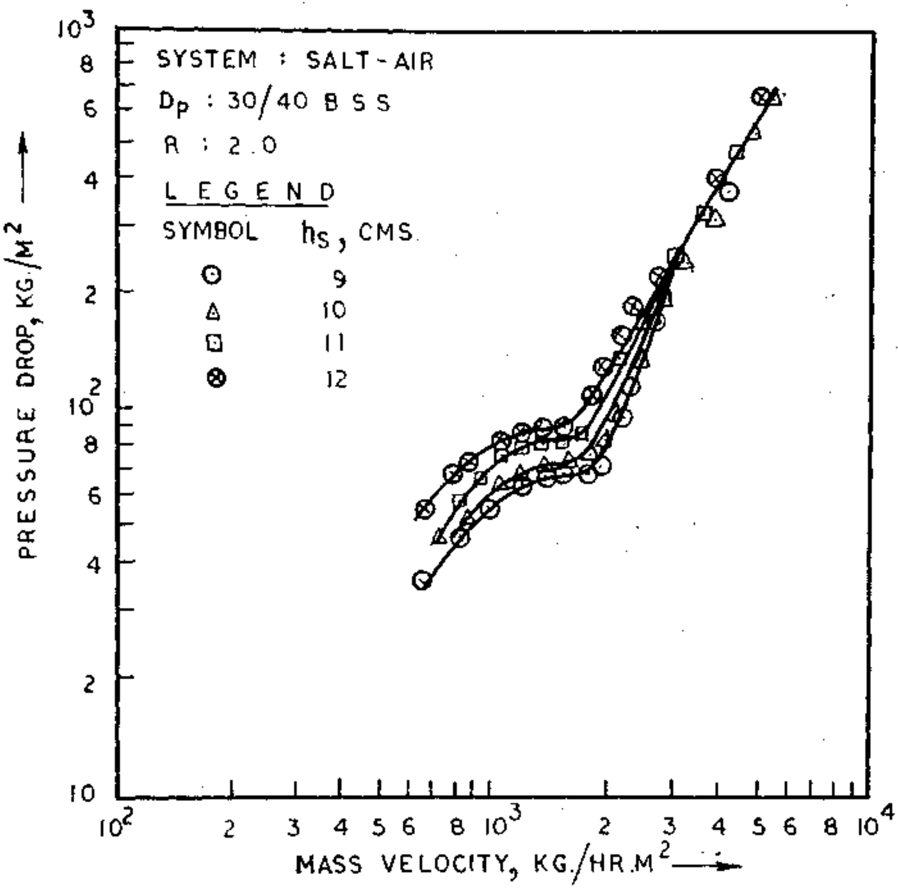


FIG. 3b₁ EFFECT OF STATIC BED HEIGHT ON MIN.M SEMI-FLUIDIZATION VELOCITY.

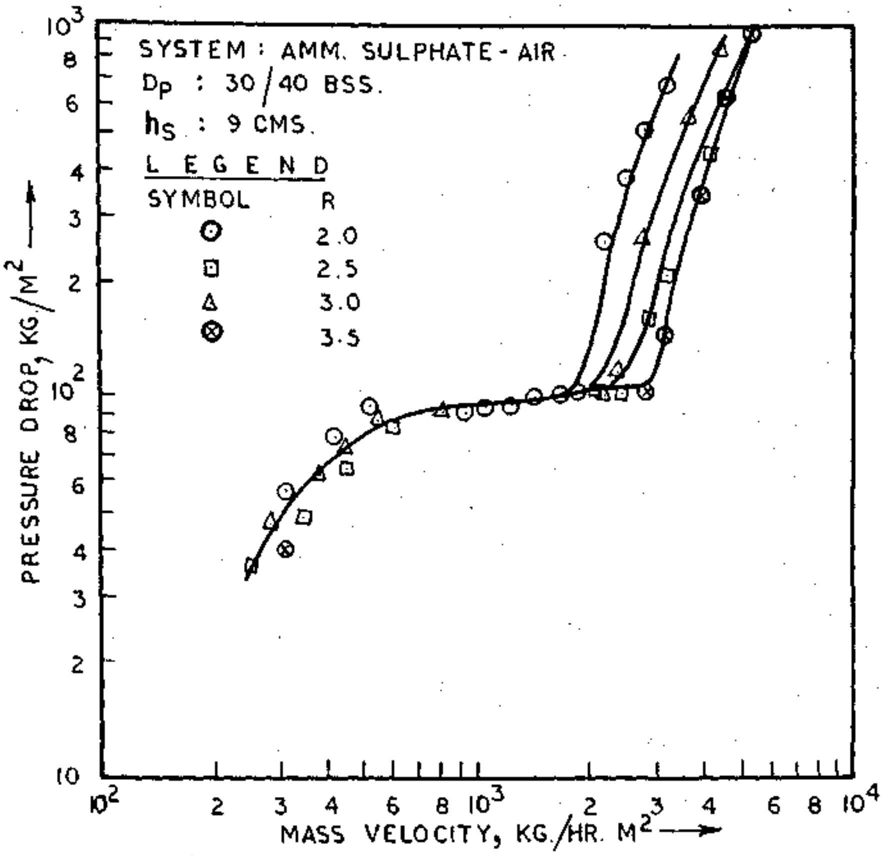


FIG. 3 b10 EFFECT OF BED EXPANSION RATIO ON MIN.M SEMI-FLUIDIZATION VELOCITY.

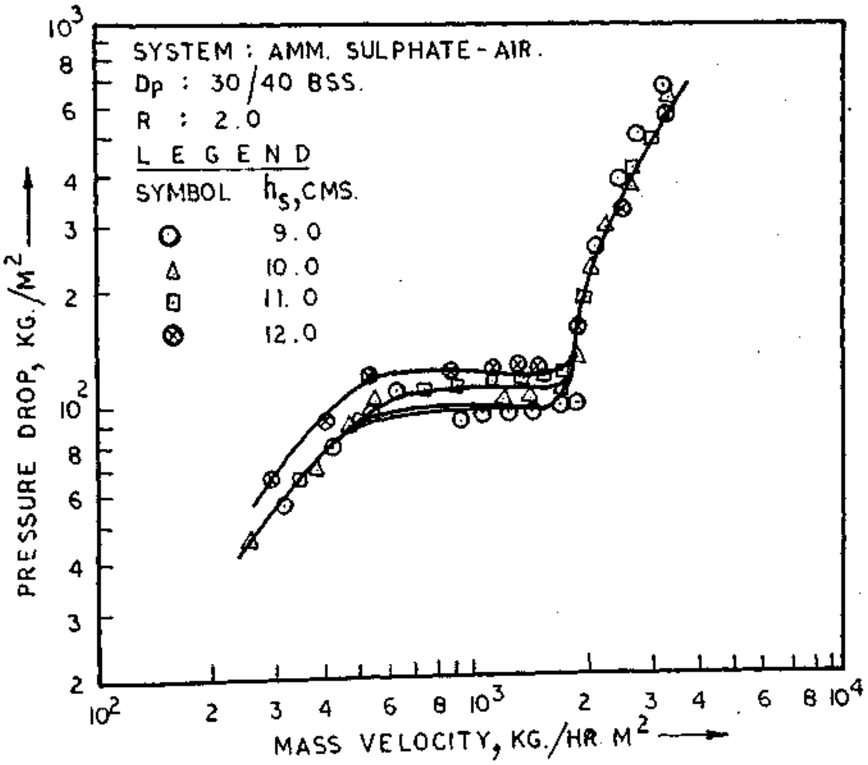


FIG. 3 b2 EFFECT OF STATIC BED HEIGHT ON MIN.M SEMI-FLUIDIZATION VELOCITY.

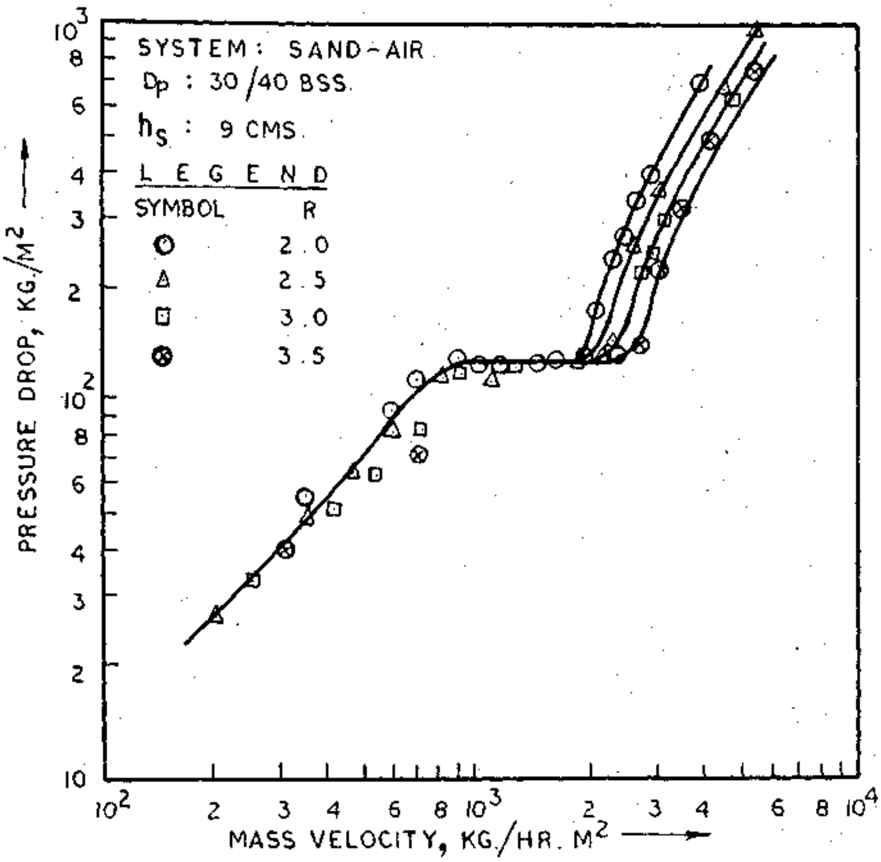


FIG. 3 b11 EFFECT OF BED EXPANSION RATIO ON MIN.M SEMI-FLUIDIZATION VELOCITY.

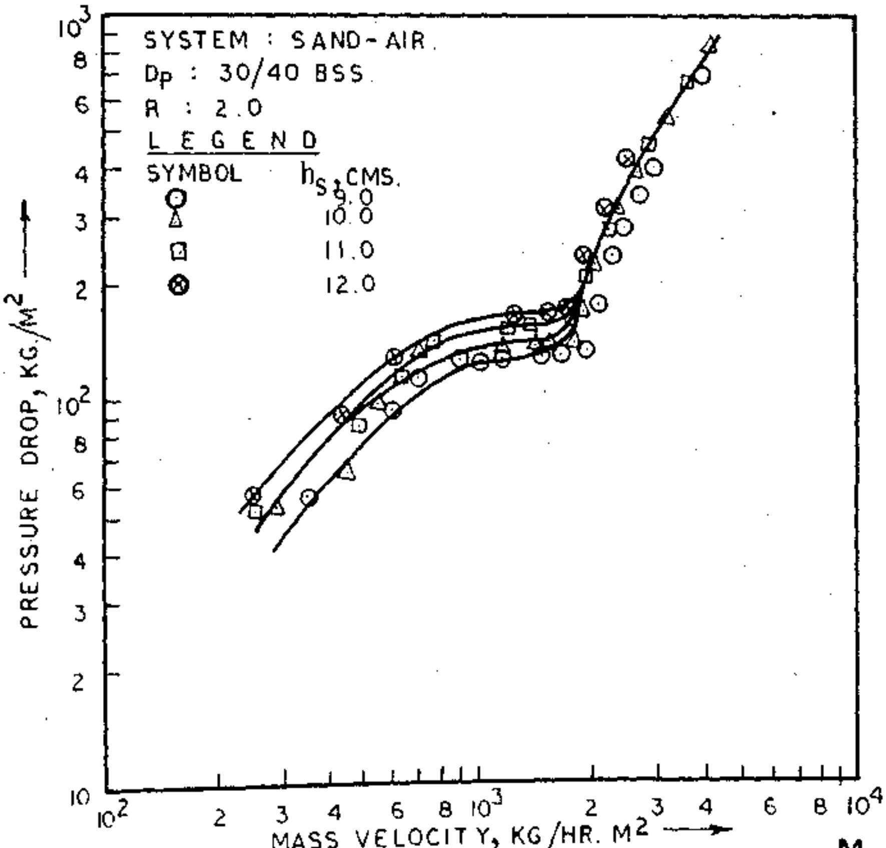


FIG. 3 b3 EFFECT OF STATIC BED HEIGHT ON MIN.M SEMI-FLUIDIZATION VELOCITY.

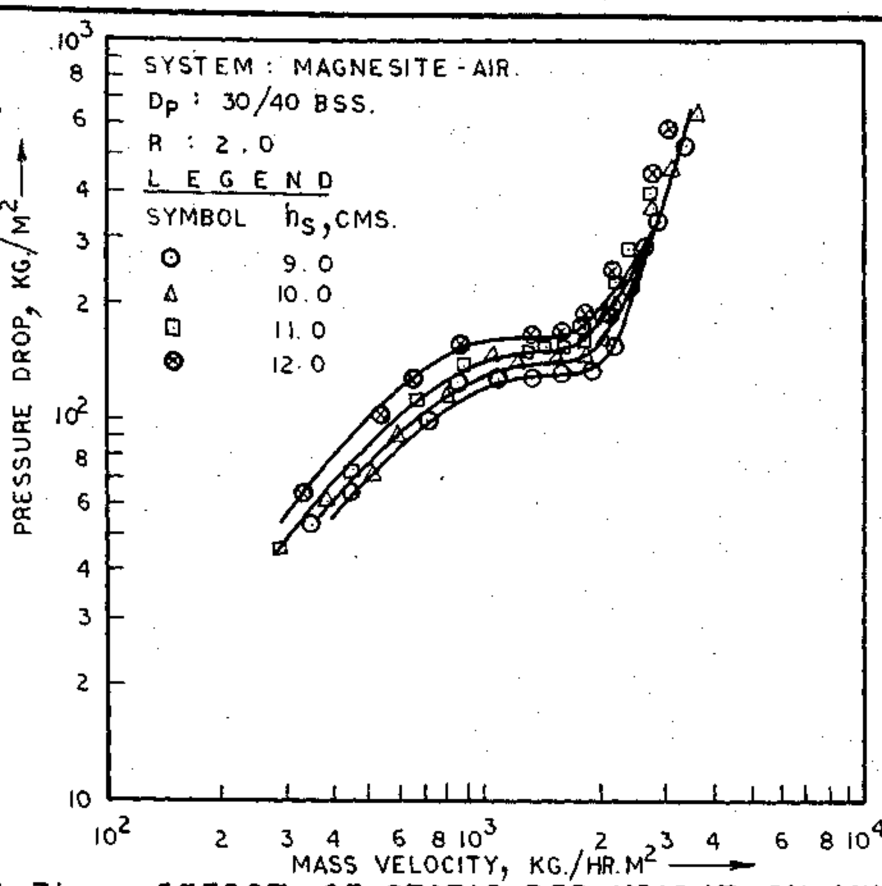


FIG. 3b4 EFFECT OF STATIC BED HEIGHT ON MIN.M SEMI-FLUIDIZATION VELOCITY.

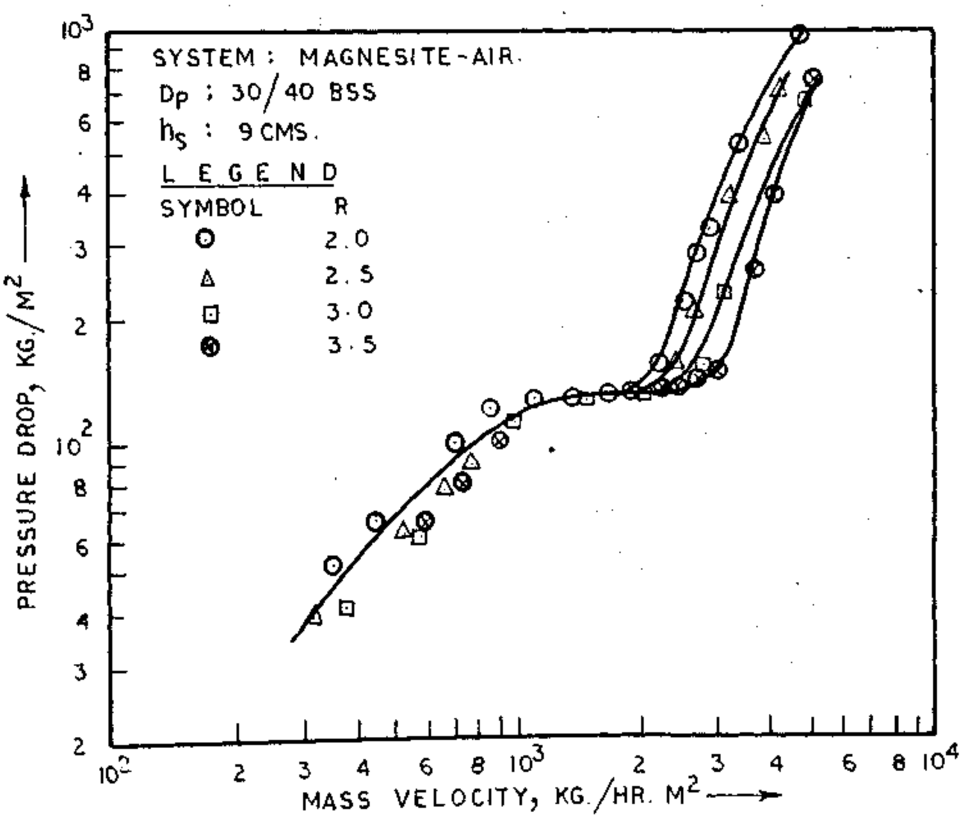


FIG. 3b12 EFFECT OF BED EXPANSION RATIO ON MIN.M SEMI-FLUIDIZATION VELOCITY.

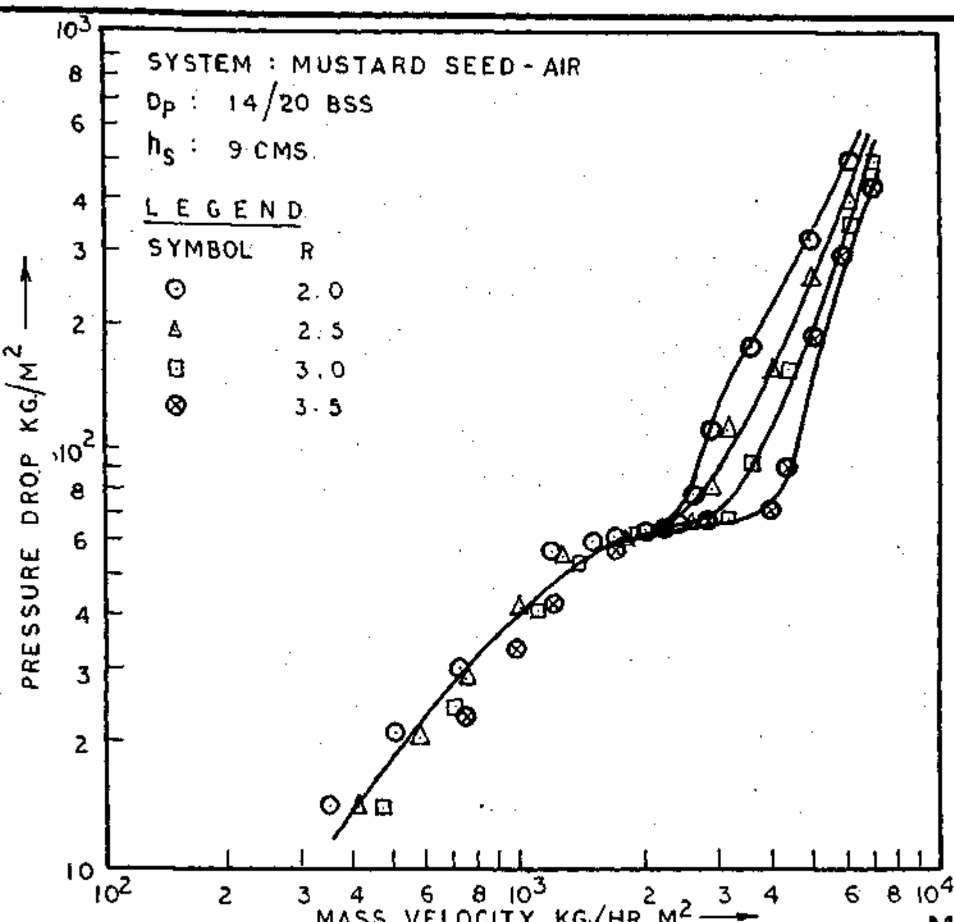


FIG. 3b13 EFFECT OF BED EXPANSION RATIO ON MIN.M SEMI-FLUIDIZATION VELOCITY.

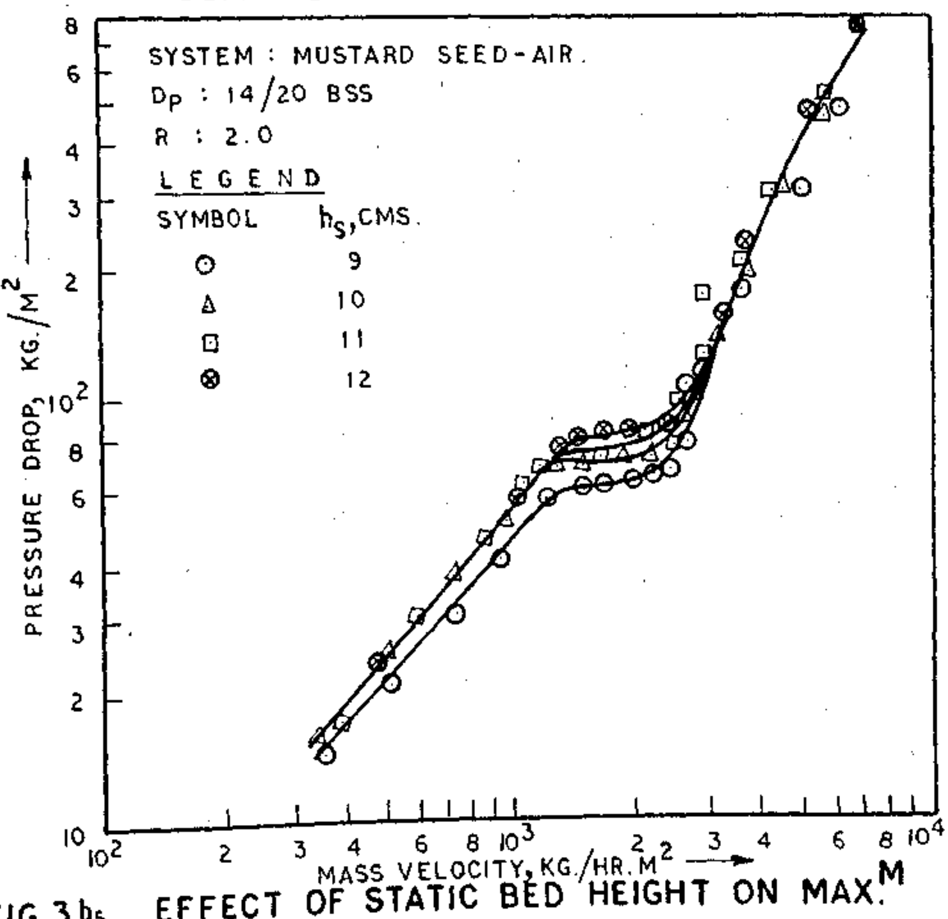


FIG. 3b5 EFFECT OF STATIC BED HEIGHT ON MAX.M SEMI-FLUIDIZATION VELOCITY.

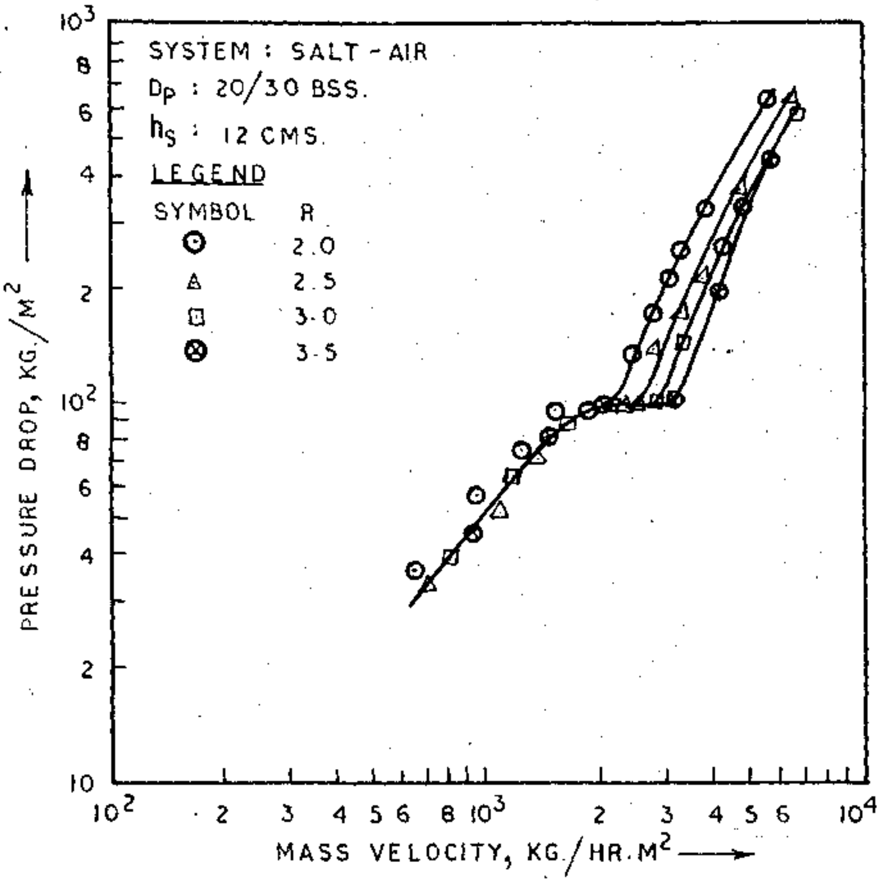


FIG. 3 b_9 EFFECT OF BED EXPANSION RATIO ON MIN.M SEMI-FLUIDIZATION VELOCITY.

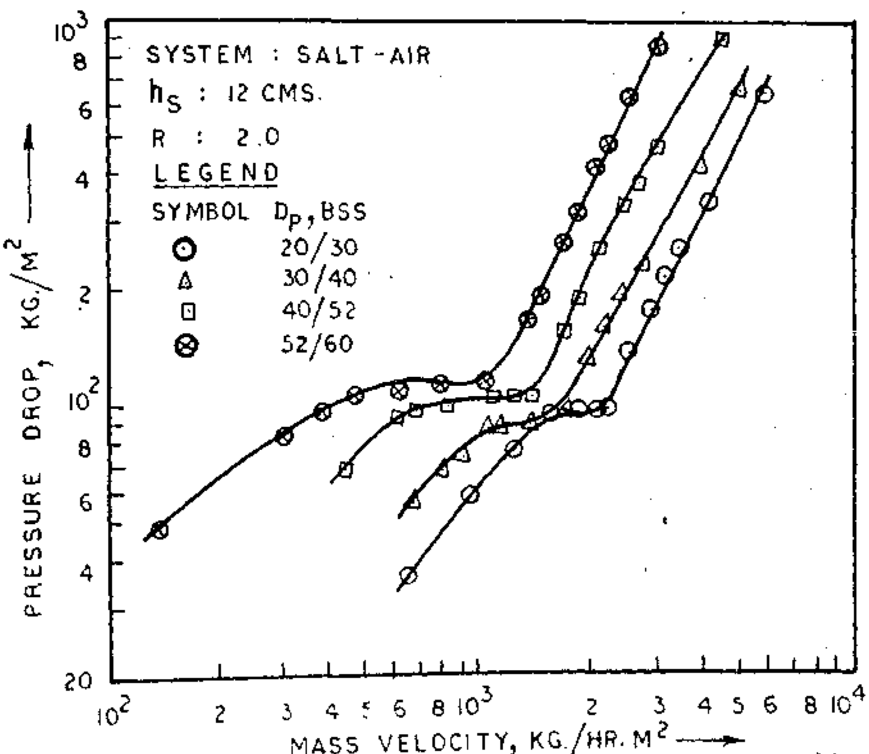


FIG. 3 b_6 EFFECT OF PARTICLE SIZE ON MIN.M SEMI-FLUIDIZATION VELOCITY.

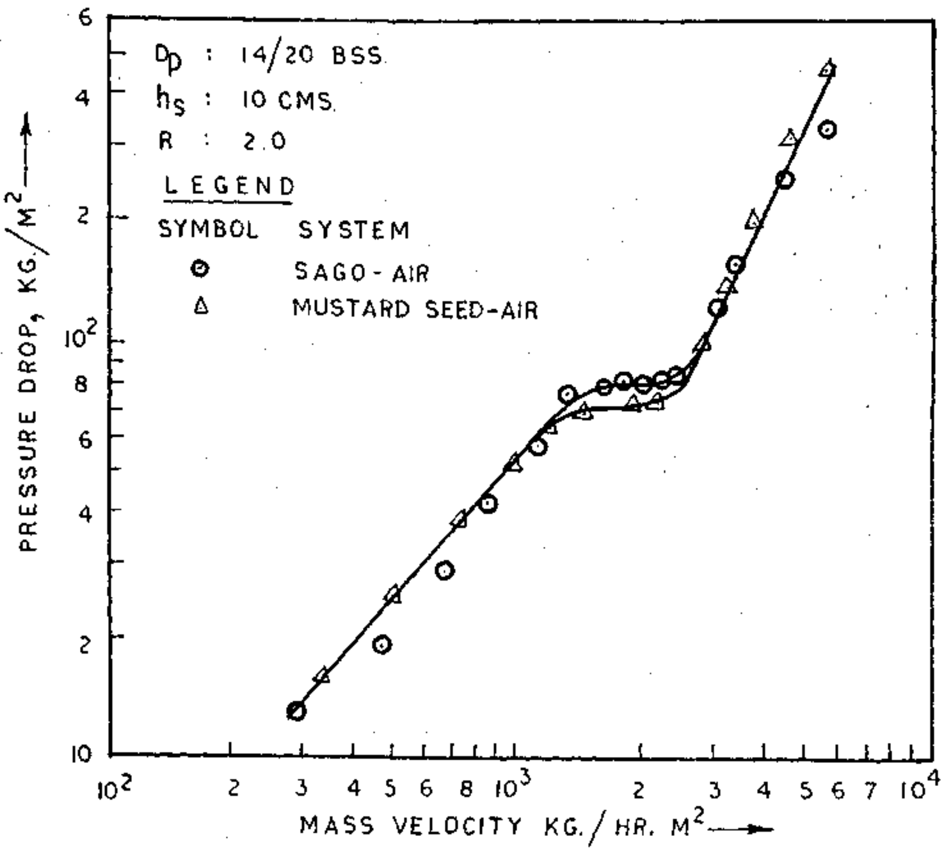


FIG. 3 b7 EFFECT OF PARTICLE DENSITY (SPHERICAL) ON MIN.M SEMI-FLUIDIZATION VELOCITY.

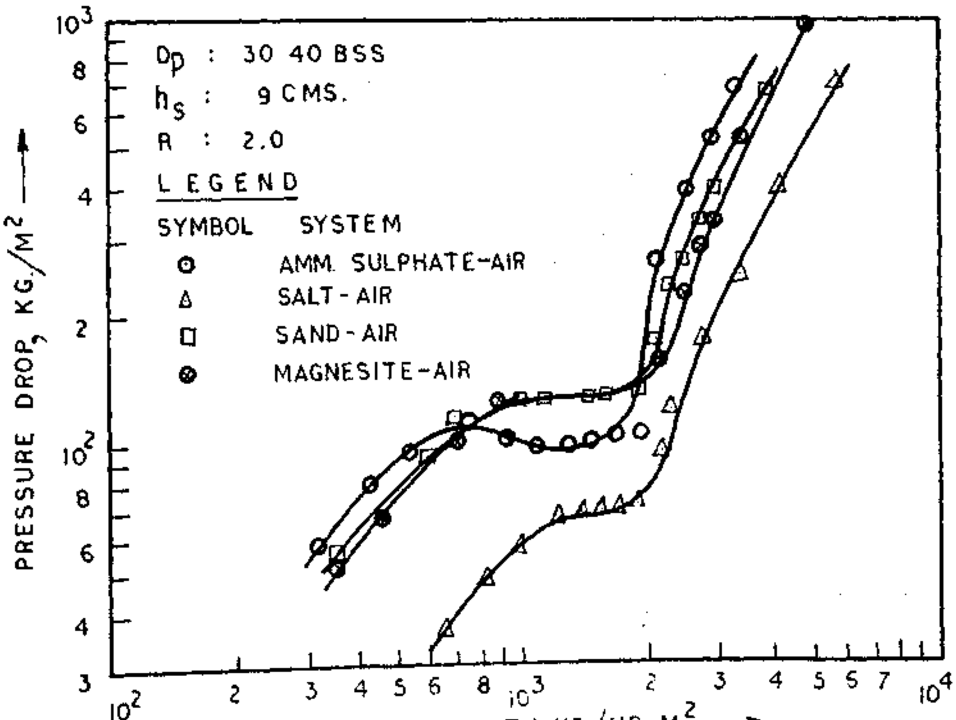


FIG. 3 b8 EFFECT OF PARTICLE DENSITY (NON-SPHERICAL) ON MIN.M SEMI-FLUIDIZATION VELOCITY.

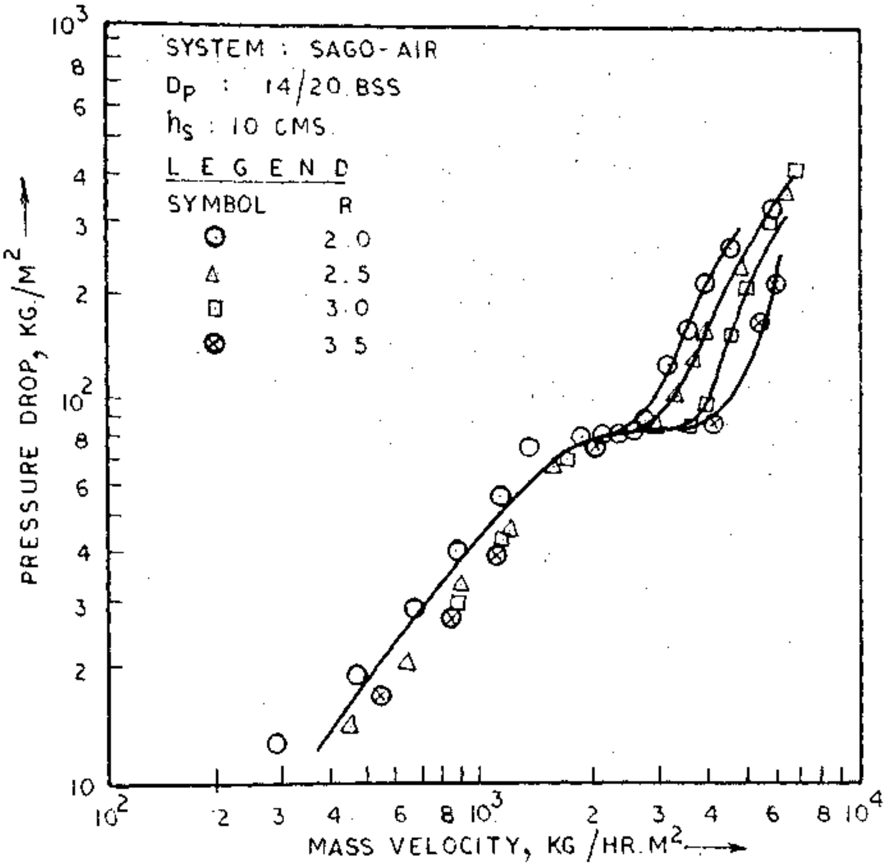


FIG. 3 b14 EFFECT OF BED EXPANSION RATIO ON MIN^{M} SEMI-FLUIDIZATION VELOCITY.

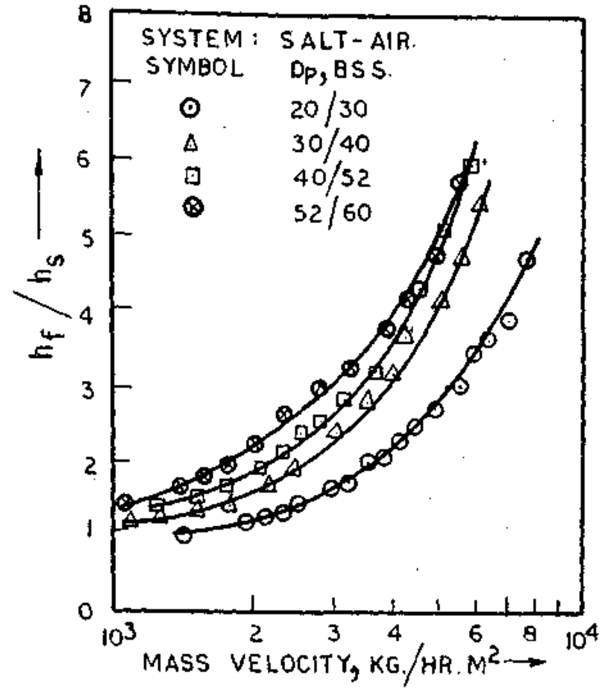


FIG. 3 b15 EFFECT OF PARTICLE (NON-SPHERICAL) SIZE ON BED EXPANSION RATIO.

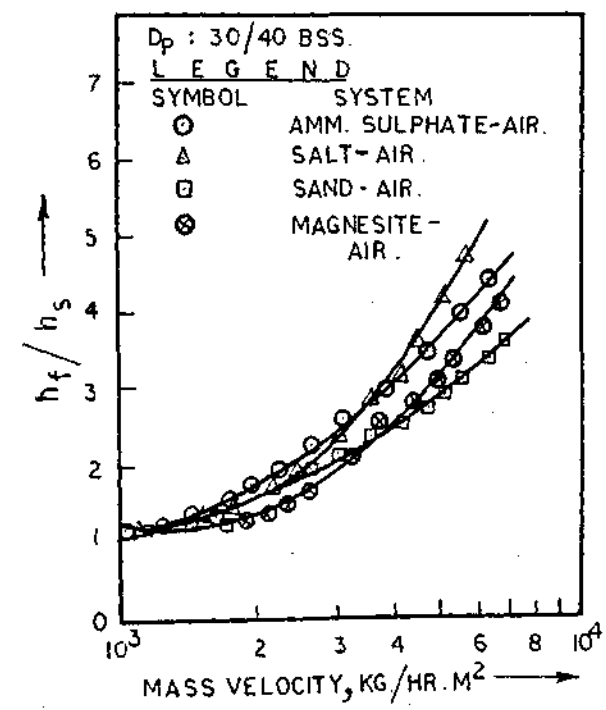


FIG. 3 b16 EFFECT OF PARTICLE DENSITY (NON-SPHERICAL) ON BED EXPANSION RATIO.

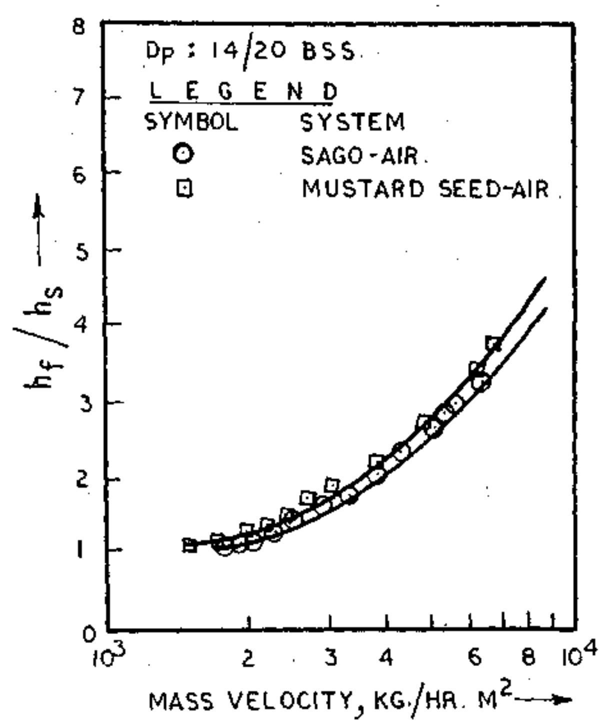


FIG. 3b17 EFFECT OF PARTICLE (SPHERICAL) DENSITY ON BED EXPANSION RATIO.

where A is a constant and a_1 , a_2 , a_3 are respective exponents of the system variables.

Effect of individual parameters :

(i) Effect of D_c/d_p on G_{osf}/G_{msf} .

Performance of a semi-fluidizer depends upon the wall-effect i.e. D_c/d_p _ ratio. From figure 3.B_6 it follows that the minimum semi-fluidization velocity is higher in case of coarser particles and inorder to study this effect on G_{osf}/G_{msf} , a plot of G_{osf}/G_{msf} against D_c/d_p (Fig. 3.B_{18}) has been "made on log-log paper. A straight line of slope 0.361 is obtained. This indicates that for higher value of D_c/d_p, the velocity ratio will increase. In other words, finer the particle size, higher will be the ratio of onset-to maximum semi-fluidization velocity for a particular semifluidizer.

(ii) Effect of density ratio (ρ_s/ ρ_f) on G_{osf}/G_{msf}

Both buoyant and drag forces are responsible for upward particle movement and will depend on a number of variables including the density ratio. Since the uplifting of the particle is to be achieved by a fluid having a different density, the particle would undergo relative displacement during forward and backward motion. The extent of back-mixing, which is a function of particle density, affects the particle equilibrium and hence the velocity ratio. From ΔP vs. mass velocity plots(Fig. 3.B_7 and 3.B_8) it can be seen that higher the density of the material higher will be onset of semi-fluidization velocity. In order to quantitatively study this effect, a plot of G_{osf}/G_{msf} vs. ρ_s / ρ_f is made on a log-log paper(Fig. 3.B). A straight line of slope -1.0 is obtained. It can be concluded that an increase in the density ratio will lead to a lower mass velocity ratio in case of semi-fluidization.

(iii) Effect of bed expansion ratio (R) on G_{osf}/G_{msf}

In case of semi-fluidization, the bed expansion ratio is of immense importance. The position of movable restraint in a semifluidizer will give quantitative idea regarding the upward lift of the particle by the fluid. The effect of bed expansion ratio has been shown in Figs. 3.B_9 - 3.B_{14} wherefrom it can be concluded that with an increase in the bed expansion ratio, the onset velocity of semi-fluidization increases. Since for a particular fluid-solid system of fixed particle size, the maximum velocity of semi-fluidization remains constant, the velocity ratio, G_{osf}/G_{msf} becomes a direct function of the bed expansion ratio.

The effect has been studied by plotting G_{osf}/G_{msf} against bed expansion ratio on a log-log paper (Fig. 3.B_{20}). A straight line of slope 0.608 is obtained. This is a clear indication of the fact that, an increase in bed expansion ratio will increase the mass velocity ratio and in turn, the onset of semi-fluidization velocity.

After substituting the exponents of the system variables, the correlation becomes,

$$\frac{G_{osf}}{G_{msf}} = A \left[\left(\frac{D_c}{d_p}\right)^{0.361} \left(\frac{\rho_s}{\rho_f}\right)^{-1.0} (R)^{0.608} \right]^B \quad \text{.. .. (3.6)}$$

where, A is the coefficient and 3 is the exponent of the overall product (Prod.) which acts as a correlation factor for the exponents of the system variables. Hence, the equation -

$$\frac{G_{osf}}{G_{msf}} = A \ (\text{Prod.})^B \quad \text{.. .. (3.7)}$$

is valid. The Tables 3.J to 3.L give the calculated values of the velocity ratio, the effect of individual parameters and the Product (Prod.).

TABLE-3.J

-Ratio of minimum to maximum semi-fluidization velocity-
(Experimental)

System	d_p m.	G_{msf} Kg/hr.m^2	R	G_{osf} Kg/hr.m^2	G_{osf}/G_{msf}
Non-spherical					
1. Table Salt-air	0.000751	14000	2.0	2200	0.157
			2.5	2650	0.189
			3.0	2900	0.208
			3.5	3250	0.232
2. Table Salt-air	0.000442	10500	2.0	1850	0.176
			2.5	2000	0.190
			3.0	2275	0.216
			3.5	2600	0.247
3. Table Salt-air	0.000338	7500	2.0	1462	0.192
			2.5	1675	0.220
			3.0	2025	0.260
			3.5	2225	0.292
4. Table Salt-air	0.000274	5500	2.0	1250	0.227
			2.5	1550	0.281
			3.0	1850	0.335
			3.5	1950	0.354
5. Ammonium Sulphate-air	0.000442	9000	2.0	1750	0.195
			2.5	2060	0.228
			3.0	2550	0.284
			3.5	2850	0.317

contd...

TABLE-3.J(contd)

System	d_p m.	G_{msf} Kg/hr.m^2	R	G_{osf} Kg/hr.m^2	G_{osf}/G_{msf}
6. Sand -air	0.000442	14000	2.0	1850	0.132
			2.5	2050	0.146
			3.0	2450	0.175
			3.5	2750	0.196
7. Magnesite-air	0.000442	15000	2.0	1875	0.125
			2.5	2100	0.140
			3.0	2500	0.167
			3.5	2900	0.193
Spherical					
8. Mustard Seed-air	0.001105	12400	2.0	2450	0.198
			2.5	2800	0.226
			3.0	3400	0.274
			3.5	4000	0.322
9. Sago - air	0.001105	14000	2.0	2500	0.179
			2.5	2900	0.207
			3.0	3500	0.250
			3.5	4100	0.293

TABLE - 3.K

Effect of various parameters on the ratio of onset of semi-fluidization to maximum semi-fluidization velocities

(a) Influence of wall effect.

Sl. No.	Operating parameter D_c/d_p	$\frac{G_{osf}}{G_{msf}}$	Constant parameter.
1	59.9	0.157	$\frac{\rho_s}{\rho_f} = 1750$
2	101.8	0.176	
3	133.0	0.192	$R = 2.0$
4	164.0	0.227	

(b) Effect of density ratio (non-spherical)

Sl. No.	Operating parameter ρ_s / ρ_f	$\frac{G_{osf}}{G_{msf}}$	Constant parameter.
1	1750	0.176	$\frac{D_c}{d_p} = 101.8$
2	1470	0.195	
3	2206	0.132	
4	2330	0.125	$R = 2.0$

(b') Effect of density ratio (spherical)

Sl. No.	Operating parameter ρ_s / ρ_f	$\frac{G_{osf}}{G_{msf}}$	Constant parameter.
1	933	0.198	$\frac{D_c}{d_p} = 40.7$
2	1087	0.179	$R = 2.0$

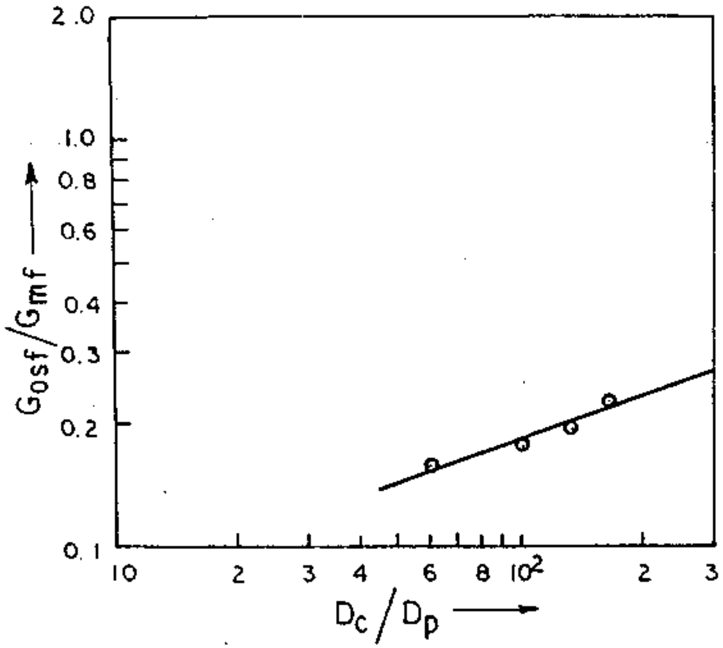
TABLE-3.K(contd.)

(c) Effect of bed expansion ratio (Non-spherical)

Sl. No.	Operating parameter, R	$\frac{G_{osf}}{G_{msf}}$	Constant parameter
1	2.0	0.176	$\frac{\rho_s}{\rho_f} = 1750$
2	2.5	0.190	
3	3.0	0.216	$\frac{D_c}{d_p} = 101.8$
4	3.5	0.247	

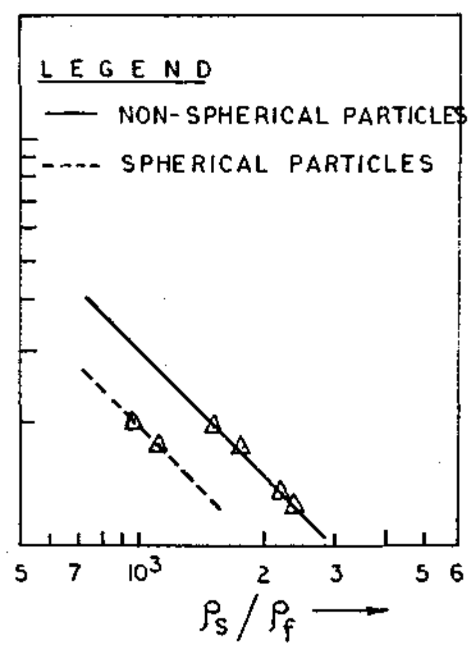
(c') Effect of bed expansion ratio - (Spherical)

Sl. No.	Operating parameter, R	$\frac{G_{osf}}{G_{msf}}$	Constant parameter.
1	2.0	0.198	$\frac{D_c}{d_p} = 40.7$
2	2.5	0.226	
3	3.0	0.274	$\frac{\rho_s}{\rho_f} = 933$
4	3.5	0.322	



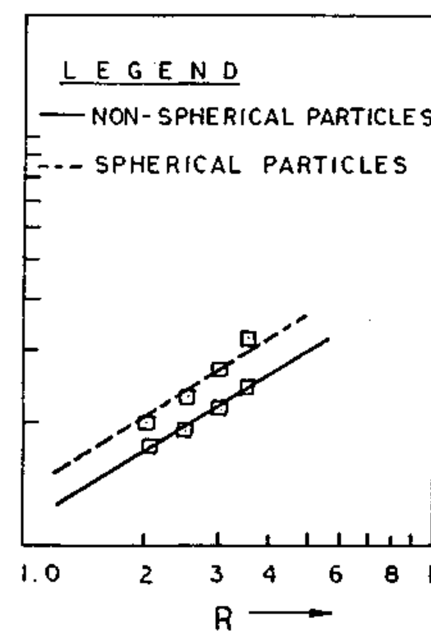
Influence of wall effect.

FIG. 3 b_{18}



Effect of density ratio.

FIG. 3 b_{19}



Effect of bed expansion ratio.

FIG. 3 b_{20}

EFFECT OF VARIOUS PARAMETERS ON MASS VELOCITY RATIO IN SEMI-FLUIDIZATION.

In Fig. 3.B_{21} , the ratio of G_{osf}/G_{msf} is plotted on a log-log paper against the product $[(D_c/d_p)^{0.361} (\rho_s/\rho_f)^{-1.0} (R)^{0.608}]$. All the data have fitted well to give a straight line of slope 1.045. The equation for the line is,

$$\frac{G_{osf}}{G_{msf}} = 48.0 \left[\left(\frac{D_c}{d_p}\right)^{0.361} \left(\frac{\rho_s}{\rho_f}\right)^{-1.0} (R)^{0.608} \right]^{1.045} \quad .. \quad .. \quad (3.8)$$

or,

$$\frac{G_{osf}}{G_{msf}} = 48.0 \left[\left(\frac{D_c}{d_p}\right)^{0.38} \left(\frac{\rho_f}{\rho_s}\right)^{1.05} (R)^{0.64} \right] \quad .. \quad .. \quad (3.9)$$

The maximum deviation is of the order of 20% . The individual deviations are given in Table 3.M.

As can be seen from Table 3.M and Fig. 3.B_{21} , the deviation is more in case of spherical particles. In the present work two spherical and four non-spherical materials have been investigated. It appears that the effect of sphericity is not very prominent, which however, has to be confirmed by further investigations.

Nomograph :

As in the case of maximum semi-fluidization velocity , a nomograph (Fig. 3.B_{22}) based on equation(3.9)has been tried for rapid prediction of minimum semi-fluidization velocity. The magnitude of maximum deviation has been of the order of 7% from the experimental value and 2.5$ from the calculated value (equ.3.9) as can be seen from Table 3.N .

TABLE -3.L

-Relation of velocity ratio (G_{osf}/G_{msf}) with system variables-

Sl. No.	D_c/d_p	$(D_c/d_p)^{0.361}$	ρ_s/ρ_f	$(\rho_s/\rho_f)^{-1.0}$	R	$R^{0.608}$	Prod.	G_{osf}/G_{msf}
Non-spherical								
1	59.9	4.36	1750	0.000571	2.0	1.525	0.00380	0.157
2	101.8	5.30	1750	0.000571	2.0	1.525	0.00461	0.176
3	133.0	5.82	1750	0.000571	2.0	1.525	0.00507	0.192
4	164.0	6.30	1750	0.000571	2.0	1.525	0.00549	0.227
5	101.8	5.30	1470	0.000680	2.0	1.525	0.00550	0.195
6	101.8	5.30	2206	0.000453	2.0	1.525	0.00366	0.132
7	101.8	5.30	2330	0.000429	2.0	1.525	0.00347	0.125
8	101.8	5.30	1750	0.000571	2.5	1.745	0.00529	0.190
9	101.8	5.30	1750	0.000571	3.0	1.950	0.00590	0.216
10	101.8	5.30	1750	0.000571	3.5	2.140	0.00648	0.247
Spherical								
11	40.7	3.81	1087	0.000920	2.0	1.525	0.00535	0.179
12	40.7	3.81	933	0.001070	2.0	1.525	0.00621	0.198
13	40.7	3.81	933	0.001070	2.5	1.745	0.00711	0.226
14	40.7	3.81	933	0.001070	3.0	1.950	0.00795	0.274
15	40.7	3.81	933	0.001070	3.5	2.140	0.00872	0.322

TABLE -3.M

-Comparison of the ratio of onset of semi-fluidization to maximum semi-fluidization velocity-

System	D_c/d_p	ρ_s/ρ_f	R	G_{osf} / G_{msf} From Expt.	G_{osf} / G_{msf} From Correlation	% deviation of calculated values from experimental
Non-spherical						
1. Table Salt-air	59.9	1750	2.0	0.157	0.141	-10.20
			2.5	0.189	0.162	-14.30
			3.0	0.208	0.182	-12.50
			3.5	0.232	0.202	-13.00
2. Table Salt-air	101.8	1750	2.0	0.176	0.165	- 6.25
			2.5	0.190	0.190	0.00
			3.0	0.216	0.214	- 0.92
			3.5	0.247	0.236	- 4.45
3. Table Salt-air	133.0	1750	2.0	0.192	0.190	-1.04
			2.5	0.220	0.220	-0.00
			3.0	0.260	0.248	-4.61
			3.5	0.292	0.274	-6.17
4. Table Salt-air	164.0	1750	2.0	0.227	0.207	- 8.80
			2.5	0.281	0.239	-14.95
			3.0	0.335	0.269	-19.70
			3.5	0.354	0.296	-16.40
5. Ammonium Sulphate-air	101.8	1470	2.0	0.195	0.207	+6.15
			2.5	0.228	0.239	+4.82
			3.0	0.284	0.269	-5.28
			3.5	0.317	0.296	-6.62
6. Sand-air	101.8	2206	2.0	0.132	0.134	+1.51
			2.5	0.146	0.155	+6.17
			3.0	0.175	0.174	-0.57
			3.5	0.196	0.192	-1.04

contd...

TABLE-3.M(contd)

System	D_c/d_p	ρ_s/ρ_f	R	G_{osf}/G_{msf} From Expt.	G_{osf}/G_{msf} From Correlation	% deviation of calculated values from experimental
7.Magnesite-air	101.8	2330	2.0	0.125	0.128	+2.40
			2.5	0.140	0.147	+5.00
			3.0	0.167	0.165	-1.20
			3.5	0.193	0.184	-4.66
Spherical						
8. Mustard Seed-air	40.7	933	2.0	0.198	0.234	+18.20
			2.5	0.226	0.270	+19.50
			3.0	0.274	0.305	+11.30
			3.5	0.322	0.338	+ 4.97
9. Sago -air	40.7	1087	2.0	0.179	0.198	+10.60
			2.5	0.207	0.229	+10.60
			3.0	0.250	0.258	+ 3.20
			3.5	0.293	0.285	- 2.73

TABLE-3.N

-Accuracy of nomograph for G_{osf} -
(In terms of % deviation)

Values of G_{osf}, Kg/hr.m^2			Percentage deviation	
Nomograph	Experimental	Calculated	From Expt.value	From Cald.value
2110	2275	2165	-7.25	-2.54

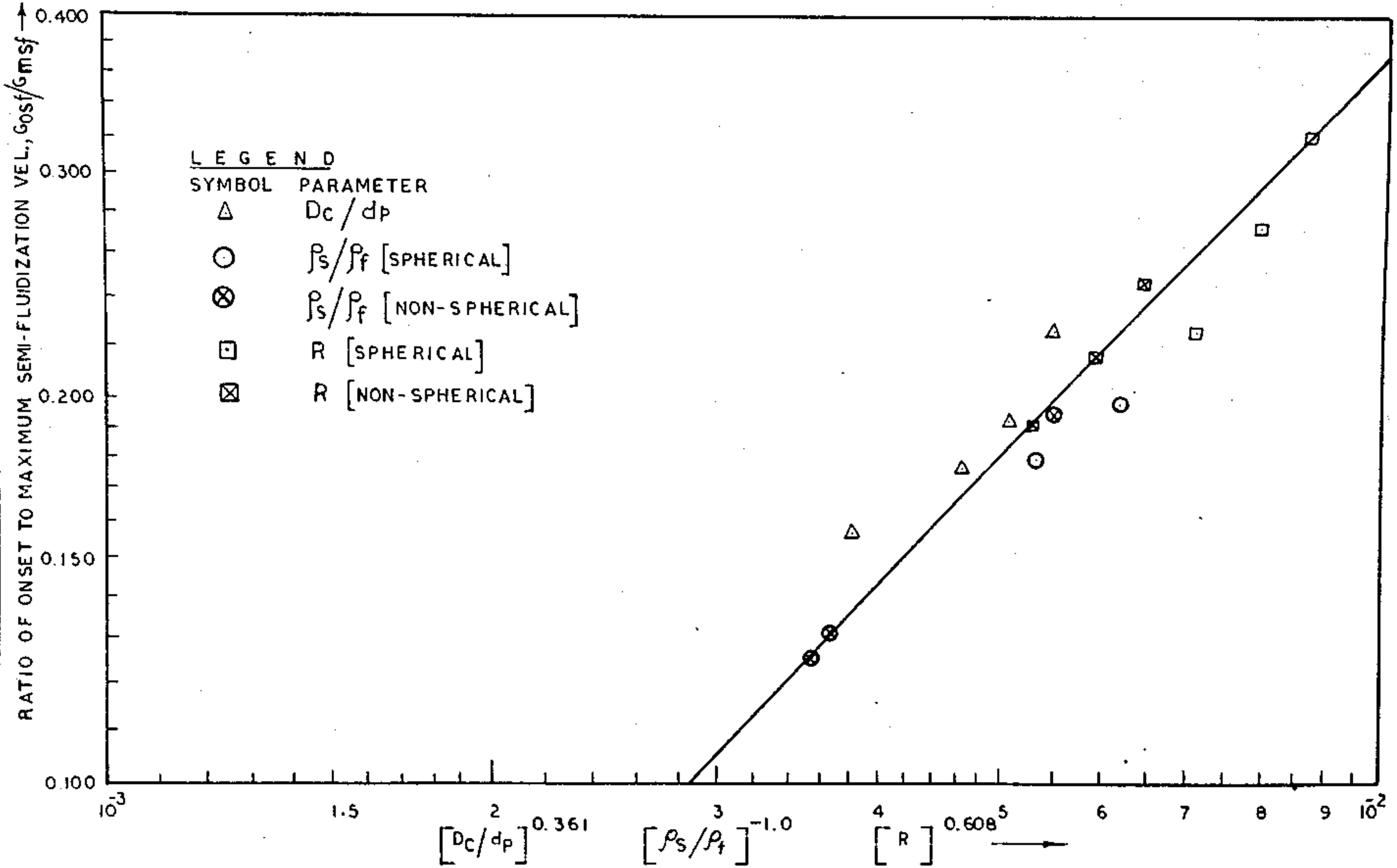


FIG. 3b$_{21}$ RELATIONSHIP BETWEEN G_{osf}/G_{msf} AND SYSTEM VARIABLES.

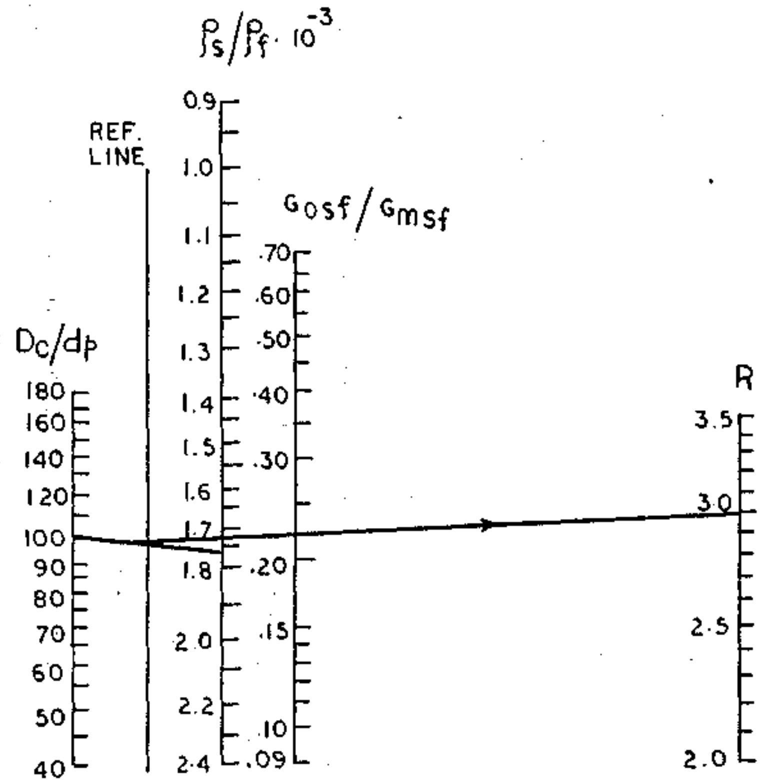


FIG. 3b21 PREDICTION OF VELOCITY RATIO IN SEMI-FLUIDIZATION.

C DEVELOPMENT OF A CORRELATION FOR THE PREDICTION OF MINIMUM SEMI-FLUIDIZATION VELOCITY FROM MINIMUM FLUIDIZATION VELOCITY.

The onset of fluidization and semi-fluidization are the two consequtive sequence of operations of the semi-fluidization phenomena. There are many correlations for the direct prediction of minimum fluidization velocity from a knowledge of the fluid and solid properties. Hence the ratio of minimum semi-fluidization velocity to minimum fluidized velocity can be related to the various parameters of the system. An attempt has, therefore, been made to develop a correlation, so that the minimum semi-fluidization velocity can be predicted from a knowledge of the system variables.

The onset of fluidization velocity can be calculated from Leva's[7] generalised equation,

$$G_{mf} = \frac{0.005 \; g \; \rho_f \; (\rho_s - \rho_f) \; d_p^2 \; \Phi_s^2}{\mu} \cdot \frac{\epsilon_{pa}^3}{1 - \epsilon_{pa}} \quad \ldots \ldots (3.10)$$

The values of the minimum fluidization velocity as calculated from the above equation along with the ratios of the onset of semi-fluidization to the onset of fluidization velocities are given in Table 3.P

The relationship between the above velocity ratio (G_{osf}/G_{mf}) and the system parameters can be written as -

$$\frac{G_{osf}}{G_{mf}} = A \left(\frac{D_c}{dp}\right)^{a_1} \left(\frac{\rho_s}{\rho_f}\right)^{a_2} (R)^{a_3} \quad \ldots \ldots (3.11)$$

TABLE-3.P

-Ratio of minimum semi-fluidization to minimum fluidization velocity-

System	dp m.	G_{mf} Kg/hr.m^2 (Cald.)	R	G_{osf} Kg/hr.m^2 (Expt)	G_{osf}/G_{mf}
Non-spherical					
1. Table Salt-air	0.000751	804	2.0	2200	2.74
			2.5	2650	3.30
			3.0	2900	3.61
			3.5	3250	4.05
2. Table Salt-air	0.000442	491	2.0	1850	3.76
			2.5	2000	4.07
			3.0	2275	4.64
			3.5	2600	5.30
3. Table Salt-air	0.000338	390	2.0	1462	3.75
			2.5	1675	4.30
			3.0	2025	5.20
			3.5	2225	5.71
4. Table Salt-air	0.000274	258	2.0	1250	4.85
			2.5	1550	6.00
			3.0	1850	7.16
			3.5	1950	7.55
5. Ammonium Sulphate-air	0.000442	349	2.0	1750	5.01
			2.5	2050	5.87
			3.0	2550	7.30
			3.5	2850	8.16
6. Sand -air	0.000442	653	2.0	1850	2.83
			2.5	2050	3.14
			3.0	2450	3.75
			3.5	2750	4.21

contd....

TABLE-3.P(contd)

System	d_p m.	G_{mf} Kg/hr.m^2 (Cald.)	R	G_{osf} Kg/hr.m^2 (Expt)	G_{osf}/G_{mf}
7. Magnesite-air	0.000442	596	2.0	1875	3.14
			2.5	2100	3.52
			3.0	2500	4.20
			3.5	2900	4.86
Spherical					
8. Mustard Seed-air	0.001105	1200	2.0	2450	2.04
			2.5	2800	2.33
			3.0	3400	2.83
			3.5	4000	3.33
9. Sago-air	0.001105	1665	2.0	2500	1.50
			2.5	2900	1.74
			3.0	3500	2.10
			3.5	4100	2.46

The effect of the individual parameters can be seen from Table $3.Q_1$ - $3.Q_3$ and by plotting the velocity ratio against the system variables on log-log papers the exponents of equation(3.11) are evaluated. After substitution of these exponents, equation (3.11) becomes,

$$\frac{G_{osf}}{G_{mf}} = A \left[\left(\frac{D_c}{d_p}\right)^{0.623} \left(\frac{\rho_s}{\rho_f}\right)^{-1.0} (R)^{0.5} \right]^{B} \quad .. \quad ..(3.12)$$

where, A is the coefficient and B is the exponent of the overall product (Prod.), which is the correlation factor for the exponents of the system variables. Hence the equation,

$$\frac{G_{osf}}{G_{mf}} = A \quad (\text{Prod.})^{B} \quad .. \quad .. (3.13)$$

is valid.

The products have been calculated and presented in Table 3.R . In fig. (3.G), the ratio of G_{osf}/G_{mf} is plotted on a log-log paper against the product $\left[(D_c/d_p)^{0.623} \, (\rho_s/\rho_f)^{-1.0} \, (R)^{0.5} \right]$. Two different straight lines, one for the spherical and the other for the non-spherical particles, have been obtained. For the non-spherical particles, the slope of the line was 1.0 and for the spherical ones, it was 1.78. Accordingly equations for these lines can be written as,
*
For spherical particles,

$$\frac{G_{osf}}{G_{mf}} = 3.4 \times 10^{3} \left(\frac{D_c}{d_p}\right)^{1.11} \left(\frac{\rho_s}{\rho_f}\right)^{-1.78} (R)^{0.89} \quad .. \quad ..(3.14)$$

For non-spherical particles,

$$\frac{G_{osf}}{G_{mf}} = 2.66 \times 10^{2} \left(\frac{D_c}{d_p}\right)^{0.62} \left(\frac{\rho_s}{\rho_f}\right)^{-1.0} (R)^{0.5} \quad .. \quad ..(3.15)$$

The values of G_{osf} calculated from the above two equations have been found to be in good agreement with the experimental data. The individual deviations are given in Table 3.S and it is seen that, the spherical materials show lesser deviations then the non-spherical ones.

TABLE - 3.Q

Effect of various parameters on the ratio of onset of semi-fluidization to onset of fluidization velocities.

(a) Influence of wall effect -

Sl. No.	Operating parameter. D_c/d_p	$\frac{G_{osf}}{G_{mf}}$	Constant parameter
1	59.9	2.74	$\frac{\rho_s}{\rho_f} = 1750$
2	101.8	3.76	
3	130.0	3.75	$R = 2.0$
4	164.0	4.85	

(b) Influence of density ratio- (non-spherical)

Sl. No.	Operating parameter, ρ_s/ρ_f	$\frac{G_{osf}}{G_{mf}}$	Constant parameter
1	1470	5.01	$\frac{D_c}{d_p} = 101.8$
2	1750	3.76	
3	2206	2.83	$R = 2.0$
4	2330	3.14	

(b') Influence of density ratio - (spherical)

Sl. No.	Operating parameter, ρ_s/ρ_f	$\frac{G_{osf}}{G_{mf}}$	Constant parameter
1	933	2.04	$\frac{D_c}{d_p} = 40.7$
2	1087	1.50	$R = 2.0$

contd...

TABLE - 3.Q(contd)

(c) Effect of bed expansion ratio - (non-spherical)

Sl. No.	Operating parameter, R	$\frac{G_{osf}}{G_{mf}}$	Constant parameter
1	2.0	3.76	$\frac{D_c}{d_p} = 101.8$
2	2.5	4.07	
3	3.0	4.64	$\frac{\rho_s}{\rho_f} = 1750$
4	3.5	5.30	

(c') Effect of bed expansion ratio - (spherical)

Sl. No.	Operating parameter, R	$\frac{G_{osf}}{G_{mf}}$	Constant parameters.
1	2.0	2.04	$\frac{D_c}{d_p} = 40.7$
2	2.5	2.33	
3	3.0	2.83	
4	3.5	3.33	$\frac{\rho_s}{\rho_f} = 933$

TABLE-3.R

-Relation of velocity ratio (G_{osf}/G_{mf}) with system variables-

Sl. No.	D_c/d_p	$(D_c/d_p)^{0.623}$	ρ_s/ρ_f	$(\rho_s/\rho_f)^{-1.0}$	R	$R^{0.5}$	Prod.	G_{osf}/G_{mf}
Non-spherical								
1	59.9	12.82	1750	0.000571	2.0	1.414	0.01038	2.74
2	101.8	17.85	1750	0.000571	2.0	1.414	0.01442	3.76
3	133.0	21.10	1750	0.000571	2.0	1.414	0.01705	3.75
4	164.0	24.00	1750	0.000571	2.0	1.414	0.01940	4.85
5	101.8	17.85	1470	0.000680	2.0	1.414	0.01720	5.01
6	101.8	17.85	2206	0.000453	2.0	1.414	0.01145	2.83
7	101.8	17.85	2330	0.000429	2.0	1.414	0.01083	3.14
8	101.8	17.85	1750	0.000571	2.5	1.581	0.01612	4.07
9	101.8	17.85	1750	0.000571	3.0	1.731	0.01767	4.64
10	101.8	17.85	1750	0.000571	3.5	1.870	0.01910	5.30
Spherical								
11	40.7	10.10	933	0.001070	2.0	1.414	0.01530	2.04
12	40.7	10.10	1087	0.000920	2.0	1.414	0.01315	1.50
13	40.7	10.10	933	0.001070	2.5	1.581	0.01710	2.33
14	40.7	10.10	933	0.001070	3.0	1.731	0.01871	2.83
15	40.7	10.10	933	0.001070	3.5	1.870	0.02020	3.33

TABLE-3.S

-Comparison of minimum semi-fluidization velocity-

System	d_p m.	R	G_{osf} From Expt. (Kg/hr.m^2)	G_{osf} From equn. (Kg/hr.m^2)	% deviation of Calc. value from experimental value.
Non-spherical					
1. Table Salt-air	0.000751	2.0	2200	2215	+ 0.70
		2.5	2650	2480	- 6.40
		3.0	2900	2715	- 6.38
		3.5	3250	2925	-10.00
2. Table Salt-air	0.000442	2.0	1850	1887	+2.00
		2.5	2000	2115	+5.75
		3.0	2275	2310	+1.27
		3.5	2600	2500	-3.84
3. Table Salt-air	0.000338	2.0	1462	1770	+21.00
		2.5	1675	1970	+17.60
		3.0	2025	2165	+ 6.90
		3.5	2225	2340	+ 5.16
4. Table Salt-air	0.000274	2.0	1250	1330	+ 6.40
		2.5	1550	1490	- 3.87
		3.0	1850	1630	-11.90
		3.5	1950	1760	- 9.75
5. Ammonium Sulphate-air	0.000442	2.0	1750	1592	- 9.04
		2.5	2050	1785	-12.90
		3.0	2550	1955	-23.40
		3.5	2850	2106	-26.10

contd....

TABLE-3.S(contd)

System	d_p m.	R	G_{osf}, Kg/hr.m^2 From Expt.	From equn.	% deviation of Expt.value from calculated value.
6. Sand - air	0.000442	2.0	1850	1985	+ 7.30
		2.5	2050	2220	+ 8.30
		3.0	2450	2428	- 0.90
		3.5	2750	2625	- 4.55
7. Magnesite-air	0.000442	2.0	1875	1720	- 8.38
		2.5	2100	1924	- 8.38
		3.0	2500	2106	-15.75
		3.5	2900	2275	-21.50
Spherical					
8. Mustard Seed-air	0.001105	2.0	2450	2375	- 3.06
		2.5	2800	2900	+ 3.57
		3.0	3400	3405	+ 0.15
		3.5	4000	3910	- 2.25
9. Sago-air	0.001105	2.0	2500	2530	+ 1.20
		2.5	2900	3080	+ 6.20
		3.0	3500	3600	+ 2.86
		3.5	4100	4160	+ 1.46

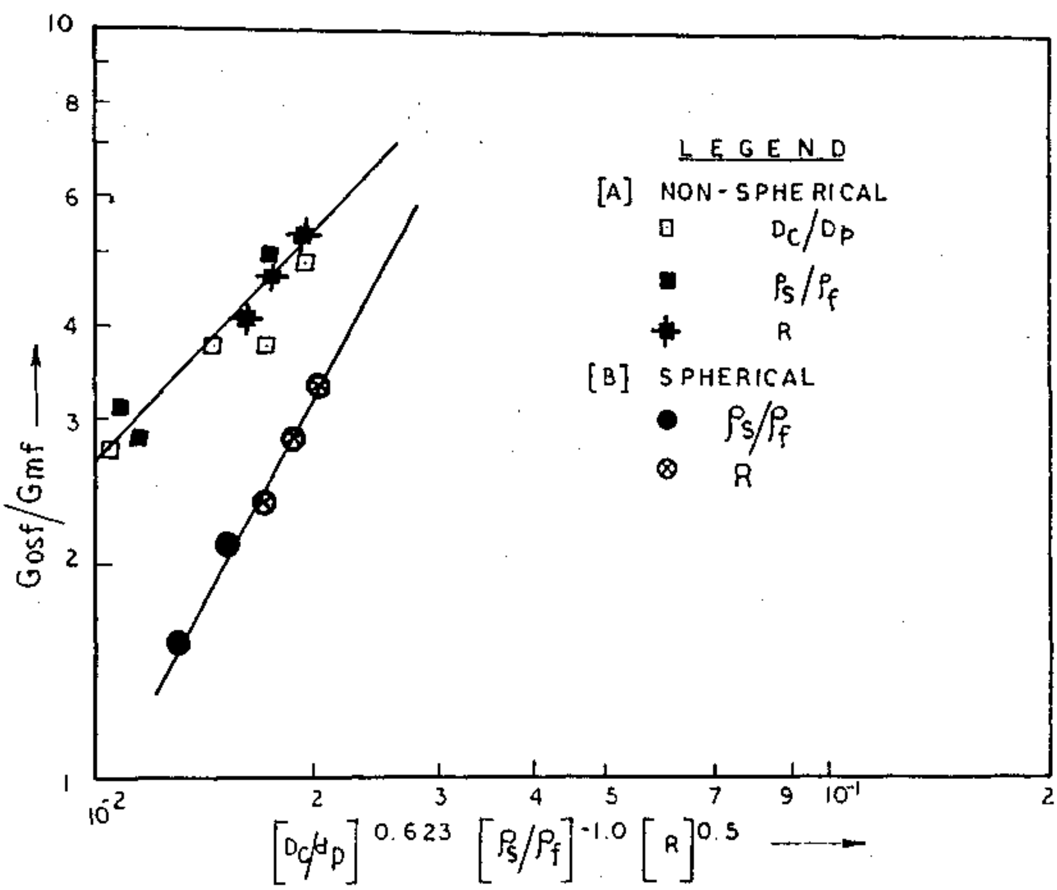


FIG. 3C RELATION OF G_{OSF}/G_{MF} WITH SYSTEM VARIABLES.

CHAPTER- IV

DYNAMICS OF SEMI-FLUIDIZATION-II

DYNAMICS OF SEMI-FLUIDIZATION II

PREDICTION OF PRESSURE DROP IN SEMI-FLUIDIZED BSD;

The pressure drop of a semifluidized bed is the algebraic sum of the pressure drop across the fluidized section and the packed section, as both are aligned in series in the direction of flow. While there is only one generaliged equation[7] namely,

$$\left(\frac{\Delta P}{L}\right)_f = (\rho_s - \rho_f)\,(1 - \epsilon_f) \qquad \ldots \quad \ldots \quad (4.1)$$

for the prediction of pressure drop across the fluidized bed,there are various correlations for the determination of packed bed pressure drop. A few important ones are -

(a) Kozney - Carman equation[24]

For laminar flow,

$$\frac{\Delta P}{L} = \frac{5\,G^2\,a}{g\,\rho_f\,\epsilon_{pa}^3}\left(\frac{G}{a\,\mu}\right)^{1.0} \qquad \ldots \quad \ldots \quad (4.2a)$$

For turbulent flow ($G/a\mu = 100$) ,

$$\frac{\Delta P}{L} = \frac{0.4\,G^2\,a}{g\,\rho_f\,\epsilon_{pa}^3}\left(\frac{G}{a\,\mu}\right)^{0.1} \qquad \ldots \quad \ldots \quad (4.2b)$$

where, a = specific surface of bed, ft^2/ft^3.

(b) Leva and co-workers[7] -

$$\frac{\Delta P}{L} = \frac{2\,f\,G^2}{g\,\rho_f\,d_p\,\varphi_s^{3-n}}\;\frac{(1 - \epsilon_{pa})^{3-n}}{\epsilon_{pa}^3} \qquad \ldots \quad (4.3)$$

where, n = 1 for laminar flow ,

= 2 for turbulent flow

f = modified friction factor

The value of 'n' and 'f' are to be determined by knowing the state of flow and referring to the standard plot of ϵ_f vs Re_p[24]

(c) Ergun' equation[7] -

$$\frac{\Delta P}{L} = 150 \frac{(1-\epsilon_{pa})^2}{\epsilon_{pa}^3} \cdot \frac{\mu u}{d_p^2} + 1.75 \frac{(1-\epsilon_{pa})}{\epsilon_{pa}^3} \cdot \frac{G u}{d_p} \quad .. \quad .. \quad (4.4)$$

In the present case,the packed bed pressure drop has been calculated using each of the above three equations for two systems (one spherical and one non-spherical) and tabulated in Table 4.A . The total pressure drop for the semifluidized bed has been obtained by adding the packed bed pressure drop in each case with the fluidised bed pressure drop obtained from equation(4.1) and these are then compared with the experimental values in Table(4.B). It is found that, use of Kozney-Carman equation gives much lower value in all cases, whereas, the equation suggested by Leva gives a few values higher than the experimental and the rest lower. Some values of pressure drops as calculated by the Ergun's equation are quite comparable. Consequently, Ergun's equation has been taken as the basis for the calculation of packed bed pressure drop in all the subsequent computations. The use of Leva's equation although somewhat justified, (because of its proximity to the experimental values) is not adopted, since, it involves quantitits like modified friction factor (f) and state of flow factor (n), which are to be taken from charts. It is difficult to read the exact values of

TABLE - 4.A.

- Comparison of pressure drops(for packed bed only) -

Spherical System: Mustard seed-air, d_p = 0.001105 m.				Non- Spherical System: Salt - air, d_p = 0.000442 m.			
Sl. No.	Pressure drop, kg/m2 By Kozney-Carman eqn.	By Leva's eqn.	By Ergun's eqn.	Sl. No.	Pressure drop, kg/m2 By Kozney-Carman eqn.	By Leva's eqn.	By Ergun's eqn.
1	2	3	4	5	6	7	8
1	2.12	7.34	6.42	1	1.63	9.35	2.01
2	11.90	22.80	21.40	2	14.75	91.00	21.90
3	35.80	97.40	85.50	3	32.70	208.00	54.50
4	60.30	155.20	135.00	4	36.80	205.50	57.60
5	69.20	159.00	139.20	5	40.50	242.00	55.00
6	146.50	385.00	336.50	6	54.20	350.00	82.90
				7	60.90	360.00	88.00
				8	81.10	517.00	133.50
				9	83.90	568.00	151.50
				10	97.00	618.00	156.30
				11	105.40	719.00	188.60
				12	116.50	783.00	206.00
				13	120.00	793.00	204.00

TABLE - 4.B

Total pressure drop of semifluidized bed

Spherical System: Mustard seed-air, d_p = 0.001105 m.				Non- Spherical System: Salt - air, d_p = 0.000442 m.			
Sl. No.	Pressure drop, kg/m^2 By Kozney-Carman eqn.	By Leva's eqn.	By Ergun's eqn.	Sl. No.	Pressure drop, kg/m^2 By Kozney-Carman eqn.	By Leva's eqn.	By Ergun's eqn.
1	58.12	73.30	62.40	1	84.60	92.30	85.01
2	65.30	76.20	74.80	2	91.85	168.10	99.00
3	87.50	149.10	137.20	3	97.20	272.50	119.00
4	107.40	202.20	182.00	4	97.70	266.40	118.50
5	110.40	200.20	180.40	5	94.40	295.90	108.90
6	175.30	413.80	365.30	6	106.70	402.50	135.40
				7	103.40	402.50	130.50
				8	119.90	555.80	172.30
				9	131.00	615.10	198.60
				10	126.20	647.20	185.50
				11	144.60	758.20	227.80
				12	147.10	813.60	236.60
				13	144.40	817.40	228.40

these quantities and any error committed here, would manifest itself in the form of wide deviation. Besides **this, Leva** has suggested different equations for packed bed pressure drop considering the effect of surface roughness(a quantity that can not he measured directly). As against all these, Ergun's equation is quite simple as it involves quantities which are directly measurable.

Correlation :

As has been reported earlier[5] and observed also in the present case, the porosity of the packed section presents difficulty for the calculation of overall pressure drop in the semifluidized bed. Available equations for packed bed pressure drops are quite sensitive to bed porosity variation. Also there are no direct ways of measuring the porosities of the fixed and the fluidized sections of the semi-fluidized bed simultaneously. This results in wide variation between the experimental and calculated values of pressure drops in a semi-fluidized bed. An attempt is made in the present work to give a correction factor in terms of system variables, which can be used for the prediction of pressure drop in the semi-fluidized bed.

The pressure drop expression can now be written as -

$$(\Delta P_t)_{expt.} = C\ (\Delta P_t)_{caln.} \qquad .. \qquad .. \qquad (4.5)$$

where, $(\Delta P_t)_{expt.}$ = experimental value of total pressure drop

$(\Delta P_t)_{caln.}$ = calculated value of total pressure drop

C = correction factor.

The expression can also be written in the form of -

$$\frac{(\Delta P_t)_{expt.}}{(\Delta P_t)_{caln.}} = C \quad .. \quad .. (4.6)$$

It is imperative that the correction factor should be related to the system parameters. The parameters of importance in this case are : h_s/D_c, ρ_s/ρ_f, h_{pa}/h_s, D_c/d_p, R.

The relation can be written in the following manner -

$$C = \psi \left[\frac{h_s}{D_c}, \frac{h_{pa}}{h_s}, \frac{D_c}{d_p}, \frac{\rho_s}{\rho_f}, R \right] .. \quad (4.7)$$

$$\text{or,} C = A \left(\frac{D_c}{d_p}\right)^{a_1} \left(\frac{\rho_s}{\rho_f}\right)^{a_2} \left(\frac{h_s}{D_c}\right)^{a_3} (R)^{a_4} \left(\frac{h_{pa}}{h_s}\right)^{a_5} ..(4.8)$$

where, A is a constant and a_1, a_2, a_3, a_4 and a_5 are respective exponents of the system variables.

The effect of the individual parameters can be seen from Table 4.C . By plotting the correction factor against each of the system variable on log-log papers, the exponents of eqn. (4.8) are evaluated. After substitution of these exponents, eqn.(4.8)becomes,

$$C = A \left[\left(\frac{D_c}{d_p}\right)^{-0.415} \left(\frac{\rho_s}{\rho_f}\right)^{0.935} \cdot \left(\frac{h_s}{D_c}\right)^{-1.614} (R)^{1.23} \left(\frac{h_{pa}}{h_s}\right)^{0.504} \right]$$

$$... \quad ..(4.9)$$

where A is the coefficient and B is the exponent of the overall product (Prod.) which is the correlation factor for the exponents of the system variables. Hence the equation,

$$C = A \; (\text{Prod.})^B \quad .. \quad ..(4.10)$$

is valid.

The products have been calculated and presented in Table 4.D . In Fig. 4.1A, and 4.1B the correction factor has been plotted on log-log papers against the product $[(D_c/d_p)^{-0.415} (\rho_s/\rho_f)^{0.935} (h_s/D_c)^{-1.614} (R)^{1.23} (h_{pa}/h_s)^{0.504}]$. Two different straight lines, one for the non-spherical and the other for the spherical particles, have been obtained. For the non-spherical particles, the slope of the line was 0.583 and for the spherical ones, it was 1.268 • Accordingly, equations for these two lines can be written as -

For non-spherical particles,

$$C = \frac{(\Delta P_t)_{actual}}{(\Delta P_t)_{cald.}} = 1.95 \times 10^{-1} [(D_c/d_p)^{-0.24} (\rho_s/\rho_f)^{0.55} (h_s/D_c)^{-0.94} (R)^{0.72} (h_{pa}/h_s)^{0.29}] \quad \ldots\ldots(4.11)$$

For spherical particles,

$$C = \frac{(\Delta P_t)_{actual}}{(\Delta P_t)_{cald.}} = 7.3 \times 10^{-3} [(D_c/d_p)^{-0.53} (\rho_s/\rho_f)^{1.18} (h_s/D_c)^{-2.05} (R)^{1.56} (h_{pa}/h_s)^{0.64}] \quad \ldots\ldots(4.12)$$

The values of the pressure drop calculated by using the above correction factors have been found to be in good agreement with the experimental data. In case of non-spherical particles most of the data lie within $\pm$ 15%, the maximum deviation being of the order of 35-40% (for a few cases only). All the system variables have been exhaustively dealt with. As ggainst this the correlation for spherical particles has limitations in that only two materials have been studied. The maximum deviation in this case is as high as 50-60%. Evidently,some more investigations with spherical particles would be needed for making definite conclusion.

TABLE - 4.C

Effect of various parameters on correction factor for pressure drop in semifluidized bed

(a) Influence of wall effect -

Sl. No.	Operating parameter, D_c/d_p	Pressure drop correction factor, C	Constant parameter
1	59.9	3.11	$\rho_s/\rho_f = 1750$
2	101.8	2.29	$h_s/D_c = 2.22$
3	133.0	2.17	$R = 2.0$
4	164.0	2.54	$h_{pa}/h_s = 0.5$

(b) Effect of density ratio (non-spherical) -

Sl. No.	Operating parameter, ρ_s/ρ_f	Pressure drop correction factor, C	Constant parameter
1	1470.0	1.41	$D_c/d_p = 101.8$
2	1750.0	2.29	$h_s/D_c = 2.22$
3	2206.0	2.74	$R = 2.0$
4	2330.0	2.72	$h_{pa}/h_s = 0.5$

(b') Effect of density ratio (spherical) -

Sl. No.	Operating parameter, ρ_s/ρ_f	Pressure drop correction factor, C	Constant parameter.
1	933.0	1.74	$R=2.0$, $\frac{h_s}{D_c}=2.22$
2	1087.0	1.43	$\frac{h_{pa}}{h_s}=0.5$, $D_c/d_p=40.7$

(c) Effect of initial static bed height (non-spherical)-

Sl. No.	Operating parameter, h_s/D_c	Pressure drop correction factor, C	Constant parameter.
1	2.00	2.41	$D_c/d_p = 101.8$
2	2.22	2.29	$\rho_s/\rho_f = 1750$
3	2.44	2.11	$R = 2.0$
4	2.66	2.12	$h_{pa}/h_s = 0.5$

TABLE-4.C(contd.)

(c') Effect of initial static bed height(spherical)-

Sl. No.	Operating parameter, h_s/D_c	Pressure drop correction factor, C	Constant parameter
1	2.00	1.35	D_c/d_p =40.7
2	2.22	1.74	ρ_s/ρ_f =933.0
3	2.44	1.91	R =2.0
4	2.66	1.34	h_{pa}/h_s =0.5

(d) Effect of bed expansion ratio (non-spherical) -

Sl. No.	Operating parameter, R.	Pressure drop correction factor, C	Constant parameter.
1	2.0	2.29	D_c/d_p =101.8
2	2.5	2.44	ρ_s/ρ_f =1750
3	3.0	2.93	h_s/D_c =2.22
4	3.5	2.68	h_{pa}/h_s =0.5

(d') Effect of bed expansion ratio (spherical) -

Sl. No.	Operating parameter, R	Pressure drop correction factor, C	Constant parameter.
1	2.0	1.74	D_c/d_p =40.7
2	2.5	2.75	ρ_s/ρ_f =933
3	3.0	1.89	h_s/D_c =2.22
4	3.5	1.99	h_{pa}/h_s =0.5

(e) Effect of packed bed formation -

Sl. No.	Operating parameter, h_{pa}/h_s	Pressure drop correction factor, C	Constant parameter.
Non-spherical			
1	0.10	1.11	
2	0.25	1.58	D_c/d_p =101.8
3	0.40	2.00	
4	0.50	2.29	ρ_s/ρ_f =1750
5	0.55	2.30	
6	0.60	2.47	h_s/D_c =2.22
7	0.75	3.00	R =2.0
8	0.80	2.93	
Spherical			D_c/d_p =40.7
1	0.40	2.65	ρ_s/ρ_f =933
2	0.50	1.74	h_s/D_c =2.22
3	0.60	1.28	R =2.0

- Relation of pressure drop correction factor(C)with system variables-

Sl. No.	$\frac{D_c}{d_p}$	$(\frac{D_c}{d_p})^{-0.415}$	$(\frac{\rho_s}{\rho_f})$	$(\frac{\rho_s}{\rho_f})^{0.935}$	$\frac{h_s}{D_c}$	$(\frac{h_s}{D_c})^{-0.614}$	R	$R^{1.23}$	$\frac{h_{pa}}{h_s}$	$(\frac{h_{pa}}{h_s})^{0.504}$	Prod	C
Non-spherical												
1	59.9	0.1800	1750	1080	2.22	0.2760	2.0	2.345	0.50	0.7055	88.9	3.11
2	101.8	0.1470	"	"	"	"	"	"	"	"	72.5	2.29
3	133.0	0.1317	"	"	"	"	"	"	"	"	65.0	2.17
4	164.0	0.1204	"	"	"	"	"	"	"	"	59.5	2.54
5	101.8	0.1470	1470	910	"	"	"	"	"	"	61.0	1.41
6	"	"	2206	1340	"	"	"	"	"	"	89.9	2.74
7	"	"	2330	1410	"	"	"	"	"	"	94.5	2.72
8	"	"	1750	1080	2.00	0.3270	"	"	"	"	86.0	2.41
9	"	"	"	"	2.44	0.2365	"	"	"	"	62.2	2.11
10	"	"	"	"	2.66	0.2060	"	"	"	"	54.2	2.12
11	"	"	"	"	2.22	0.2760	2.5	3.090	"	"	95.6	2.44
12	"	"	"	"	"	"	3.0	3.860	"	"	119.8	2.93
13	"	"	"	"	"	"	3.5	4.660	"	"	144.5	2.68
14	"	"	"	"	"	"	2.0	2.345	0.10	0.3130	32.2	1.11
15	"	"	"	"	"	"	"	"	0.25	0.4975	51.2	1.58
16	"	"	"	"	"	"	"	"	0.40	0.6300	64.8	2.00
17	"	"	"	"	"	"	"	"	0.55	0.7400	76.1	2.30
18	"	"	"	"	"	"	"	"	0.60	0.7730	79.5	2.47
19	"	"	"	"	"	"	"	"	0.75	0.8652	89.0	3.00
20	"	"	"	"	"	"	"	"	0.80	0.8937	91.9	2.93
Spherical												
21	40.7	0.2150	933	640	2.22	0.2760	2.0	2.345	0.50	0.7055	63.0	1.74
22	"	"	1087	690	"	"	"	"	"	"	67.9	1.43
23	"	"	933	640	2.00	0.3270	"	"	"	"	74.5	1.35
24	"	"	"	"	2.44	0.2365	"	"	"	"	54.0	1.91
25	"	"	"	"	2.66	0.2060	"	"	"	"	47.0	1.34
26	"	"	"	"	2.22	0.2760	2.5	3.090	"	"	82.9	2.75
27	"	"	"	"	"	"	3.0	3.860	"	"	103.5	1.89
28	"	"	"	"	"	"	3.5	4.660	"	"	125.0	1.99
29	"	"	"	"	"	"	2.0	2.345	0.40	0.6300	56.2	2.65
30	"	"	"	"	"	"	"	"	0.60	0.7730	69.0	1.28

TABLE-4.D

-Relation of pressure drop correction factor with system variables-

(Additional Data)

Sl. No.	Spherical: Product (Prod.)	Spherical: Pressure drop correction factor, C	Sl. No.	Non - spherical: Product (Prod.)	Non - spherical: Pressure drop correction factor, C
1	54.3	1.16	1	26.8	1.15
2	60.9	1.23	2	27.0	1.19
3	75.5	1.54	3	23.1	1.30
4	73.1	1.66	4	37.4	1.38
5	84.6	1.99	5	38.2	1.49
6	88.5	2.09	6	52.0	1.50
7	100.0	2.36	7	51.1	1.57
8	78.1	2.40	8	54.2	1.56
9	92.5	2.67	9	25.8	1.64
10	107.3	2.73	10	44.1	1.88
			11	53.0	1.89
			12	73.9	1.95
			13	45.9	1.95
			14	45.8	1.96
			15	73.0	2.10
			16	77.7	2.28
			17	67.5	2.41
			18	106.5	2.46
			19	97.5	2.50
			20	111.0	2.51
			21	70.1	2.55
			22	75.0	2.66
			23	82.2	2.72
			24	96.0	2.99
			25	115.4	3.00
			26	123.0	3.03
			27	125.1	3.03
			28	123.7	3.06
			29	151.0	3.16
			30	111.8	3.21
			31	134.2	3.30
			32	141.0	3.70
			33	197.0	3.74
			34	160.0	4.10
			35	170.8	4.15
			36	163.0	4.18
			37	220.5	4.29
			38	197.0	4.33
			39	182.5	4.82

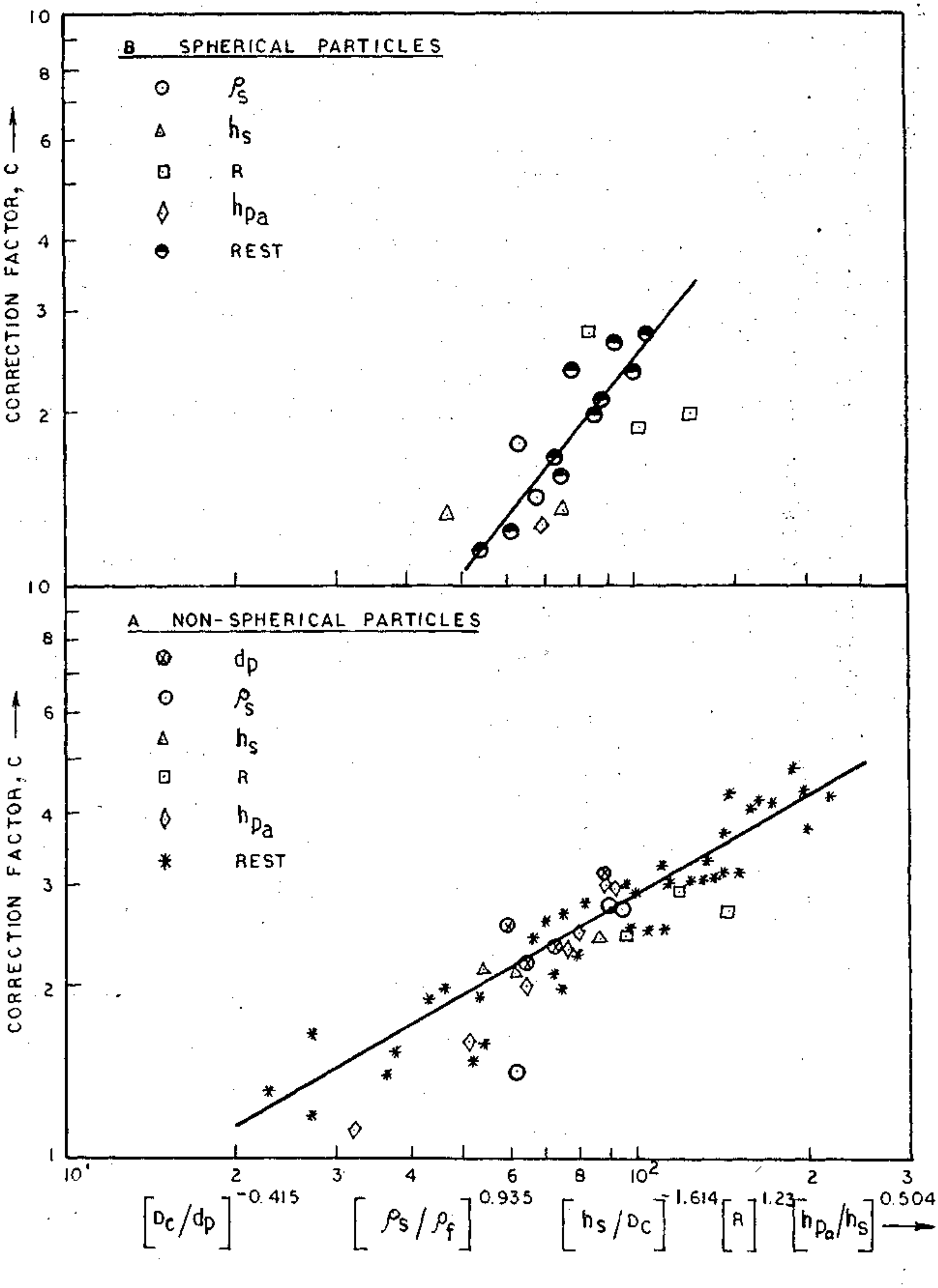


FIG. 4·1 RELATION OF 'C' WITH SYSTEM VARIABLES.

N O M E N C L A T U R E

A = Cross section of column, L^2

Ar = Archimedes number, dimensionless group,
$d_p^3 \rho_s (\rho_s - \rho_f) g/\mu^2$

B = Exponent of correlation factor

BSS = British standard sieve

C = Constant of equation

C_d = Drag coefficient

D = Diameter of reactor, L

D_c = Diameter of column, L

d_p = Particle diameter, L

f = Function

g_c = Gravitational constant, $L\theta^{-2}$

G = Mass velocity of fluid, $M\theta^{-1}L^{-2}$

Ga = Galileo number, dimensionless group,
$d_p^3 \rho_f (\rho_s - \rho_f) g/\mu^2$

G_{mf} = Minimum fluidization velocity, $M\theta^{-1}L^{-2}$

G_{msf} = Maximum semi-fluidization velocity, $M\theta^{-1}L^{-2}$

G_{osf} = Onset (minimum) velocity of semi-fluidization, $M\theta^{-1}L^{-2}$

G_{sf} = Semi-fluidization velocity, $M\theta^{-1}L^{-2}$

G_t = Free fall terminal velocity of particle (also called maximum semi-fluidization velocity) $M\theta^{-1}L^{-2}$

G_t' = Superficial maximum semi-fluidization velocity obtained from extrapolation of h_{pa}/h_s vs G curve, $M\theta^{-1}L^{-2}$

G_t'' = Terminal velocity of particle obtained by fluidization experiment (also called balancing velocity) $M\theta^{-1}L^{-2}$

h = Overall height of column (or semifluidized bed), L

h_s = Height of initial static bed, L

h_{pa} = Height of packed section in semifluidized bed, L

h_f = Height of fully fluidized bed, L

h' = Height of fluidized bed in restricted fluidization, L

J_d = Mass transfer factor,

K = Constant

MT = Mixed and tubular reactor

Nu_p = Particle Nusselt number, hd_p/k

ΔP_f = Pressure drop through fluidized section of semifluidized bed, FL^{-2}

$(\frac{\Delta P}{L})_f$ = Pressure gradient across fluidized bed, FL^{-3}

ΔP_{pa} = Pressure drop through packed section of semifluidized bed, FL^{-2}

$(\frac{\Delta P}{L})_{pa}$ = Pressure gradient across packed bed, FL^{-3}

ΔP_t = Overall pressure drop through the semifluidized bed, FL^{-2}

R = Bed expansion ratio in semi-fluidization, dimensionless

Re_m = Modefied Reynolds number, dimensionless, $\frac{6\,G}{\mu\,\varphi_s\,S_o}$

Re_{msf} = Reynolds number at maximum semi-fluidization velocity, dimensionless, $d_p\,G_{msf}/\mu$

Re'_{msf} = Modified Reynolds number at maximum semi-fluidization velocity, dimensionless, $6\,G_{msf}/\mu\,\varphi_s\,S_o$.

Re_{osf} = Reynolds number at minimum semi-fluidization velocity, dimensionless, $d_p\, G_{osf}/\mu$

Re'_{osf} = Modified Reynolds number at minimum semi-fluidization velocity, dimensionless, $6\, G_{osf}/\mu\, \varphi_s\, S_o$

Re_p = Particle Reynolds number, dimensionless $d_p G/\mu$

Re_t = Reynolds number corresponding to termminal velocity of particle, dimensionless, $d_p\, G_t/\mu$

S_f = Semi-fluidization group, $(W_s - W_p)/(h-h_s)^3\, \rho_s$

S_o = Surface area of partiċle per unit volume of solid, L^2/L^3

u = Linear velocity of fluid, $L\theta^{-1}$

u_t = Terminal velocity of particle in fluid, $L\theta^{-1}$

W = Total weight of solid in the column, M

W_p = Total weight of solid in the packed, bed section in semi-fluidization, M

W_s = Initial weight of solid in static bed, M.

X = Weight fraction of particle in packed section.

Greek letters

Δ = Finite change of variable

α = constant

β = Constant

ψ = Function

ϕ = Function

φ_s = Sphericity of particles

μ = Viscosity, $ML^{-1}\theta^{-1}$

ρ = Density, ML^{-3}

ϵ = Bed porosity, dimensionless

Subscripts :

avg.	=	Average
b	=	Bed
c	=	Column (Semifluidizer)
f	=	Fluid or fluidized bed
m	=	Modified
mf	=	Minimum fluidization condition
osf	=	Onset(minimum) of semi-fluidization condition
msf	=	Maximum Semi-fluidization condition
sf	=	Semi-fluidization condition
pa	=	Packed bed
p	=	Particle
t	=	Terminal value

R_E_F_E_R_E_N_C_E_S

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APPENDIX

- APPENDIX - A

A typical experimental run along with some sample calculations are given below :

Run No. $S_3/h_{s4}/R_4$

System: Table salt-air Particle size: 40/52 BSS

h_s = 12 cms. h = 42 cms; R = 3.5 t = 24°C

Sl. No.	Manometer readings								Packed bed formation, h_{pa} cms.
	M_1* Cms. of CCl_4		M_2** Cms. of CCl_4		M_3* Cms. of Hg		M_4** Cms. of Hg		
	h_1	h_2	h_1	h_2	h_1	h_2	h_1	h_2	
1	32.6	33.4	25.20	27.70	-	-	-	-	-
2	32.3	33.7	24.70	28.20	-	-	-	-	-
3	31.6	34.4	32.90	29.00	-	-	-	-	-
4	30.7	35.3	23.20	29.80	-	-	-	-	-
5	26.7	39.4	23.15	29.85	-	-	-	-	-
6	20.3	45.9	23.10	29.90	-	-	-	-	-
7	13.8	52.5	23.05	29.95	-	-	-	-	-
8	11.0	56.3	21.30	31.70	-	-	-	-	-
9	-	-	-	-	34.9	41.1	34.5	36.0	2.0
10	-	-	-	-	33.3	42.6	34.1	36.4	3.0
11	-	-	-	-	31.9	43.9	33.6	36.8	4.8
12	-	-	-	-	27.4	48.3	32.1	38.1	6.0
13	-	-	-	-	23.6	51.8	31.3	38.9	7.2

* Manometers for orifice pressure drop
** Manometers for bed pressure drop

Sample calculations :

For mass velocity -

$$G = \frac{W}{A}$$

Dia of semifluidizer = 4.5 cms.

Area of cross-section = $\frac{\pi}{4}(4.5)^2 \times (\frac{1}{100})^2$

$= 0.00159 \ m^2$

so, $G = \frac{W}{0.00159} = 629 \ W.$

where, W = flow rate of air, kg/hr. (from calibration chart)

For pressure drop -

(i) 76 cms. of Hg. = 1 atm. = 14.7 lb/cm^2

1 cms. of Hg. $= \frac{14.7 \times 144}{76} \times \frac{3.28^2}{2.204}$

$= 136 \ kg/m^2$

So, $\Delta P = 136 \ \Delta h_1$

where, ΔP is in kg/m^2

Δh_1 is in cms. of Hg.

(ii) $\Delta h_2 = \Delta h_1 \times \frac{\rho_{Hg}}{\rho_{CCl_4}}$

$= \frac{\Delta p}{136} \times \frac{13.6}{1.585}$

$\Delta P = 136 \times \frac{1.585}{13.6} \ \Delta h_2$

$= 15.85 \ \Delta h_2$

where, Δh_2 is in cms. of CCl_4

APPENDIX - B

DETERMINATION OF SURFACE AREA OF SOLIDS BY AIR PERMEABILITY METHOD.

Theory:

The rate of flow of fluid through a bed of particles is a function of various factors such as voidage, the pressure drop across the bed, the viscosity of the fluid, area of the bed and specific surface of the particles. Kozney derived the following relationship between the velocity of the fluid through the bed of particles and other factors from the basic equation of flow of fluid through the empty tube,

$$u = \frac{d^2}{\eta\, k_1} \left(\frac{\Delta P}{L} \right)_g \qquad \text{..} \qquad \text{..} \qquad (1)$$

where u = velocity of fluid, cm/sec.

d = diameter of the pipe, cm

η = viscosity of the fluids, poise

$\frac{\Delta P}{L}$ = rate of pressure drop per unit length of pipe.

He assumed that the fluid flows through the bed in the form of channels and the total internal surface and total internal volume and equal to the particle surface and the pore volume respectively.

The equivalent diameter, m' is defined as

$$m' = \frac{\text{cross sectional area normal to flow}}{\text{perimeter presented to the fluid}}$$

Thus for a bed of grannular particles, contained in the pipe of uniform cross section it can be shown that ,

$$m' = \frac{\epsilon}{(1-\epsilon)\, S_v} \quad .. \quad .. \quad (2)$$

where is the porosity of the bed, and

S_v is the surface area of the particles per unit

Volume of solids.

Hence, the equivalent velocity, u_e, is

$$u_e = \frac{1}{\eta\, k_1} \cdot \frac{\epsilon^2}{(1-\epsilon)^2} \; \frac{1}{S_v^2} \; \left(\frac{\Delta P_g}{L}\right) \quad .. \quad .. \quad (3)$$

Now as the path of the channels is not straight, but of sinuous nature, the equivalent length of the channel, L_e should be used in place of measured length of the bed, L, hence we have,

$$u_e = \frac{1}{\eta\, k_1} \; \frac{\epsilon^2}{(1-\epsilon)^2} \; \frac{1}{S_v^2} \; \frac{\Delta P_g}{L_e} \quad .. \quad .. \quad (4)$$

Also, if u is the velocity of fluid based on the tube diameter then,

$$u_e = \left(\frac{u}{\epsilon} \; \frac{L_e}{L}\right) \quad .. \quad .. \quad (5)$$

Thus from equations (4) and (5) we have

$$u = \frac{\epsilon^3}{S_v^2\,(1-\epsilon)^2\, k_1 \eta} \; \left(\frac{\Delta P_g}{L}\right) \left(\frac{L}{L_e}\right)^2 \quad .. \quad .. \quad (6)$$

Carman found that the value of the factor $\left[\frac{1}{k_1}\left(\frac{L}{L_e}\right)^2\right]$ is equal to(1/5)for a wide range of experimental conditions, hence,

$$u = 0.2\,\frac{\epsilon^3\, \Delta P_g}{S_v^2\,(1-\epsilon)^2\, \eta\, L} \quad .. \quad .. \quad (7)$$

Thus,

$$S_v = \sqrt{\frac{\epsilon^3}{(1-\epsilon)^2} \quad \frac{1}{5\,u\,\eta} \quad \frac{\Delta P_g}{L}} \qquad \ldots \quad \ldots \quad (8)$$

If the manometer is used to measure the ΔP then,

$$\Delta P = h_1 \; \rho_1 \qquad \ldots \quad \ldots \quad (9)$$

where, h_1 is the difference in the heights of the fluid in manometer

ρ_1 is the density of the manometer fluid

If A is the cross-section of the bed, and Q is the volumetric flow rate of fluid, then,

$$u = \frac{Q}{A} \qquad \ldots \quad \ldots \quad (10)$$

For air flow, the capillary flowmeter can be used for the measurements of the volumetric flow rate. By using the equation for stream line flow we have air flow rate,

$$Q = C \; \frac{h_2 \; \rho_2}{\eta} \qquad \ldots \quad \ldots \quad (11)$$

where, C is the flow meter constant,

h_2 is difference in the level of the manometer used with flow meter, and

ρ_2 is the density of the fluid of manometer.

Hence, from equations 8, 9, 10 and 11,

$$S_v = \frac{14}{(1-\epsilon)} \sqrt{\frac{\epsilon^3 \; A \; h_1 \; \rho_1}{CL \; h_2 \; \rho_2}} \qquad \ldots \quad \ldots \quad (12)$$

If the fluids in both the manometer are same, then,

$\rho_1 = \rho_2$, and

$$S_v = \frac{14}{(1-\epsilon)L} \sqrt{\frac{\epsilon \; V_b}{C} \quad \frac{h_1}{h_2}} \qquad \ldots \quad \ldots \quad (13$$

where, V_b is the bed volume, cc

Thus from Equation (13) the surface area of the solids per unit volume can be calculated from the knowledge of void fraction, ϵ, bed height, L, bed volume, V_b, flowmeter constant, C and the pressure drops across the bed and flowmeter.

The value of 'C' in these experiments has been taken as 48.72×10^{-6}.

Determination of surface area of non-spherical particles

Sl. No.	Materials	d_p, cm.	wt. of sample gms.	Bed height L, cm.	Bed volume, V_b cc	Solid volume, V_s, cc.	ϵ_{pa}	h_1 cm	h_2 cm	$\frac{h_1}{h_2}$	$(\frac{h_1}{h_2})_{av.}$	S_v cm^2/cc
1	Table salt	0.0751	33.341	35.2	38.2	15.90	0.584	2.1	5.1	0.412	0.407	241.0
								2.4	5.9	0.406		
								2.6	6.5	0.400		
								3.0	7.3	0.411		
								3.2	7.9	0.405		
								3.4	8.3	0.409		
2	"	0.0442	35.300	38.4	41.5	16.80	0.595	2.6	4.1	0.634	0.622	300.5
								3.1	4.9	0.632		
								3.6	5.9	0.610		
								4.2	6.9	0.610		
3	"	0.0338	24.810	23.7	25.7	11.82	0.540	3.6	5.2	0.692	0.663	302.0
								4.0	5.8	0.690		
								4.2	6.4	0.656		
								4.6	7.0	0.657		
								5.2	8.0	0.650		
								5.8	9.2	0.630		
4	"	0.0274	40.270	37.2	40.2	19.16	0.524	4.5	2.9	1.550	1.520	335.0
								5.5	3.5	1.570		
								6.3	4.1	1.530		
								6.7	4.5	1.490		
								8.1	5.5	1.470		
5	Ammonium sulphate	0.0442	39.400	34.4	37.3	22.3	0.402	4.3	5.4	0.796	0.791	136.0
								4.5	5.6	0.804		
								5.4	6.8	0.795		
								6.1	7.8	0.781		
								7.1	9.1	0.780		
6	Sand	0.0442	50.680	31.4	38.9	19.13	0.435	3.0	3.6	0.833	0.813	170.5
								3.5	4.2	0.833		
								5.0	6.2	0.807		
								5.5	6.7	0.821		
								5.8	7.2	0.805		
								6.6	8.2	0.805		
7	Magnesite	0.0442	54.290	32.9	35.7	19.40	0.453	4.3	5.6	0.768	0.763	177.0
								4.7	6.2	0.759		
								5.3	6.9	0.769		
								5.5	7.2	0.764		
								5.7	7.5	0.760		
								6.5	8.6	0.755		